Teacher's Manual for

ND WHY EXPERIMENTS

The HOW AND WHY ScienceBooks

Frasier

A TEACHER'S MANUAL
AND SCIENCE HANDBOOK
to accompany

HOW AND WHY EXPERIMENTS
BOOK V

of the

HOW AND WHY SCIENCE SERIES

including also

A KEY TO THE COMPANION BOOK

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THE HOW AND WHY SCIENCE BOOKS

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"All knowledge begins in wonder."

ELEMENTARY SCIENCE

THE PHILOSOPHY OF SCIENCE TEACHING

Someone has said, "All knowledge begins in wonder." A child entering school for the first time brings with him spontaneous enthusiasm and interest in the world about him which manifest themselves in an eagerness to relate his experiences. He is full of questions about the caterpillars, frogs, turtles, and other live things that he finds as he plays. He is curious about the weather, the heavenly bodies, and other physical phenomena of his environment. He asks how and why the mechanical devices of his everyday experiences work.

Too often this natural curiosity of the little child is lost instead of being developed during the first few years of school life, because teachers and parents feel their inadequacy to meet the situation. The knowledge required to answer all these questions is so great as to discourage the average adult. When children are curious, they have no respect for the lines of subject matter. One question may fall in the field of biology; the next in physics or chemistry. To

answer all questions completely might well require more knowledge than even a specialist would possess.

However, to teach science to children it is not necessary to be able to answer all their questions. The alert teacher with abundant enthusiasm and curiosity can help them find the answers to many of their own questions. Nowhere will her efforts bring more satisfying results than in the teaching of science.

The philosophy of science teaching differs very little from that of any other subject. It is the subject matter which makes the handling of it more difficult, because teachers are not generally trained for science teaching. The teacher must take into account those things in the child's experience which lie in the field of science. There are many experiences common to children everywhere that may become the foundations of our science work. From these common paths teachers may diverge with the interests of individuals and the groups, and adapt the teaching to the local community or section of the country.

We live in a world that is changing so rapidly that what is grist for the science mill today may become a waste product tomorrow. One day a Byrd explores Antarctica; a Beebe explores the depths of the ocean; or a Piccard penetrates the stratosphere. At such times even first-graders may discuss the stratosphere but to put the stratosphere into a first-grade book, in the light of our present knowledge, would be questionable.

Again, the children we teach are affected by varied environments. Those of the western plains have a whole set of animal concepts not possessed by children of the Atlantic coast. Children in a mining town, children from the country, children from a metropolis—all have experiences which give them different ideas. But through all these experiences the teachers may teach the same scientific principles. For example, hibernation of animals may be taught to a western child by a study of snakes; to a child in the lake region by a study of frogs; to a child somewhere else by the study of clams, crayfish, or some insect.

In science, the teacher needs to remember individual differences. Some children respond more freely to experiences with plants, some to animals, some to physical science. By encouraging children to express themselves freely in the classroom, and to experi-

ment for themselves with the materials found in the science room, the teacher can discover these differences and make effective uses of them.

Above all, to be a successful teacher of science, one must be enthusiastic about the subject, enjoy working with children, and understand the way they think. She must be scientific in her own attitudes and be able to use the problem-solving method of teaching. She does not have to be a specialist in science nor be afraid that she won't know all the answers. She probably won't be able to answer all the questions which the children ask, but even if she can, to do so would spoil the fun for the children. She need not hesitate to say, "I don't know," providing she continues, "but we'll find out together." Science teaching can be a shared experience of teacher and children that has great possibilities for both.

OBJECTIVES FOR TEACHING SCIENCE TO CHILDREN

Science for the grades should not be regarded as a mere accumulation of facts but as a series of experiences with the science materials that are a part of every child's daily life. These experiences stimulate the curiosity of children and if used properly should lead to behavior changes in the children. To accomplish desirable outcomes the teacher should understand the reasons why anyone studies science. These reasons may be called objectives. Scientists differ in the way they state these major objectives, but they agree on their content. Briefly stated, these objectives of elementary science are:

1. To develop an intelligent appreciation of the natural and physical world.
2. To develop scientific attitudes.
3. To help children acquire the scientific method of problem solving.
4. To help children acquire useful science concepts.

By an intelligent interest and appreciation of the world in which he lives, a child is made aware of beauty that goes deeper than

the mere appeal to the senses. Appreciation should grow as knowledge is gained. The person who gets a satisfaction from the color and form of a beautiful butterfly should enjoy it more after seeing its transformation from pupa to adult. The child who, looking intently at a butterfly's chrysalis, exclaimed, "Oh, I can see the wings through the chrysalis skin!" was experiencing appreciation. Children should get a thrill out of their science experiences which will make their lives richer and more enjoyable.

Appreciation should lead to the conservation of wild life. The biological principles of the struggle for existence and survival of the fittest tend toward a balance in nature, unless man upsets the balance. Through experiences with material such as that used in "Insects in the Garden," "Birds in the Orchard," and "Life in the Pond," children may be led to see the relationships of plants and animals. They learn which ones are harmful, and what to do about them, as well as which ones are helpful to man.

The second objective, that concerning scientific attitudes, should run through all science teaching. The child who develops scientific attitudes:

(*a*) Will have a conviction of basic cause-and-effect relationships which will make it impossible for him to believe in superstition or unexplained mysteries.
(*b*) Will have a sensitive curiosity which will lead to making accurate observations, collecting data, and searching for adequate explanations.
(*c*) Will have the habit of delayed response, preventing him from making snap judgments or jumping to conclusions.
(*d*) Will weigh evidence carefully to find out if it is sound, pertinent, and adequate.
(*e*) Will have respect for another's point of view, and be willing to change his point of view in the face of new evidence.

These may sound formidable to the teacher who has had little training in science. She may recognize them as desirable outcomes, yet not have the slightest idea of how to go about teaching them. She need not be frightened, however, because the techniques by which she helps children develop scientific attitudes are

very similar to those she uses to develop social attitudes. The first step is to be able to recognize a *lack* of the attitudes.

For example, a child who says, "My grandmother says the ground hog saw his shadow and he can tell about the weather," has not developed the attitude of looking for a cause. The teacher could help him develop the attitude by saying, "That is interesting. I wonder what makes your grandmother think that," or, "I wonder how the ground hog (woodchuck) knows." The child may answer, "If he sees his shadow on ground-hog day, we'll have six weeks of bad weather." Then the teacher may say, "That may be true, but what do the rest of you think about it?" After a brief discussion she may say, "All of you are just giving ideas. Is that the way scientists (or people who study woodchucks) would settle a question?" The children may suggest watching for woodchucks or discussing the weather on February 2—will the woodchuck see his shadow or not? They may watch the weather for six weeks, recording it and comparing the actual weather with the woodchuck's "prediction." Some child may be bright enough to remark, "It may be cloudy in the fields south of town and the sun may be shining on the north side. The north side couldn't have six weeks of bad weather while the south side is having good weather." The grandmother (who would have resented it had the teacher said, "That idea is not true, Tom,") may become interested in a long-time experiment; but, whether or not there is hope for grandmother, Tom's plastic mind has been affected by six weeks of observing and checking.

Later when Dick insists that horsehairs turn into snakes, Tom will be eager to bring rain water and a horsehair to find out if Dick is right. Bit by bit, these experiences will straighten out Tom's thinking until one day he will say, "I don't believe in superstitions. One day when we were out driving, a black cat ran across the road. Later we had engine trouble, but the trouble was caused because a part had worn out."

Not only is this attitude taught by correcting existing superstitions and misconceptions, but it impels children to look for the causes of all natural phenomena. Numerous opportunities arise every day to develop it. For example, in trying to solve the problem of why food spoils, the teacher may ask, "Where does your

Independent investigations.

mother put food that she wants to keep?" Through discussion someone may say, "Temperature will affect food. When food gets hot, it spoils." In problem solving there are many opportunities to teach scientific attitudes.

The ability to interpret natural phenomena correctly does away with unreasoning fears. The child who understands the cause of thunder, and has demonstrated the sound in a small way by clapping his hands, is not so likely to be afraid of it. Knowing that animals are not likely to sting or bite except in self-defense, he is less susceptible to the fear carried by many people into adult life. The person who has studied about meteors and northern lights doesn't assign mysterious reasons or results to these natural phenomena. The child's understanding of the cause and prevention of disease helps keep him from carelessly exposing himself and others, as in the case of colds. He learns that everything has a cause; that disasters don't just happen, nor, as was once believed, are they visited upon us as punishment.

Curiosity concerning their environment is natural to children, though some have more of it than others. But sensitive curiosity may have to be taught. Children ask many questions to which they really don't expect an answer, nor care for one. Sensitive

curiosity is demonstrated by a perseverance on the part of the child in asking a question, or in independent investigation on his own initiative. Children should be given opportunities to tell of things they observe that stimulate their interest and curiosity. If learning is dependent upon desire to know, then curiosity is a valuable attitude to develop. Some children have it to such a degree that no amount of squelching on the part of adults will stop their investigations. They learn in spite of their teachers. Other timid ones stop asking when they get no satisfactory explanation. The child who persisted in saying, "I *want* to *know* what makes the bubbles in cake," after the teacher had told her it was too hard for her to understand, had unquenchable curiosity.

The ability to make accurate observations and the ability to collect data are outcomes of the attitude of sensitive curiosity. Some techniques which help in the teaching of this attitude are:

(*a*) Making use of the children's suggestions of ways to collect data—for example, when Mary wonders what will happen if a prism is held in a cloud of dust while a sunbeam is striking it, let Mary try the demonstration, using chalk dust.

(*b*) Insisting upon accurate descriptions when a child reports having seen something—for example, when a boy describing an insect the size of a gnat, tells of a yellow stripe around its body, the teacher may say, "Just a minute. How could you see the yellow stripe on an insect no larger than a gnat? Tell just what you saw. If you didn't see the color, don't tell about it."

(*c*) Setting an example of collecting data by asking questions about many points which the children have not mentioned in their descriptions.

(*d*) Insisting upon experimentation or demonstration being directed to the purpose of gaining adequate explanations. Children are likely to become more interested in the working of the apparatus than in the answer to their original question. Then the teacher may say, "Why are we doing this experiment? Is it helping to answer the question? It is an experiment only as long as you are learning. After that it is play."

The attitude of delayed response is developed by insisting on the children's not "jumping to conclusions." The child who says, "I saw a bird. I *think* it was a woodpecker because it was tapping on a tree," or "I *think* the fish died because we didn't put any green stuff in the aquarium like we do at home," or "I'm *not sure,* but I don't think the air does all of the work of holding the plane up," has developed the attitude. The child who says, "I *know* that was a fallen star. There are a lot of them around here," hasn't developed the attitude.

To help develop the attitude of delayed response, the teacher must be on the alert with answers such as:

"We must be careful and not think we have found out something when we really haven't."

"Do you think you should say they are fallen stars? Has anyone proved it?"

"Let's save that question and answer it later. Then we will find out more about it to help us be sure." (And don't forget to do it!)

Having developed the attitudes of basic cause and effect, sensitive curiosity, and delayed response, children are ready for weighing evidence. Children are usually eager to express their ideas without thought as to whether they are pertinent or sound. When the teacher is just starting her science program, she may encourage expression to get things under way. After the ice is broken and the children are no longer inhibited or shy, the teacher has to curb their enthusiasm and direct their thinking.

To do this without breaking their line of reasoning takes skill. The teacher must not be discouraged if her first attempts at developing attitudes result in confusion. She may have to go back to the beginning of the lesson and start over. When this happens, the teacher should take the children into her confidence by smiling and saying, "I guess I got us off on the wrong track. Let's see where we were," or "We're all mixed up. You'll have to help me. What were we trying to find out?" The children will respond to this.

Some ways to help develop this attitude of weighing evidence are to give suggestions like:

"Let's remember not to take too much time with details that don't really have anything to do with our problem."

"Does your question have anything to do with electricity? Have you thought it through?"

"Do you think that we have enough information to answer the question?"

"Should we decide before we know what a scientist has to say about that?"

"Let's keep our minds on one track."

By consulting an authority, the teacher should check often on the accuracy and soundness of the experiments being done. The children should check with their science texts. They should never draw conclusions from one experiment.

A child who has developed this attitude will say things like this: "I think the tooth comes from the upper jaw by the way it curves. If you'll look at a dog's teeth, you'll notice that the upper teeth curve down over the lower teeth. It's hard to tell whether it's the upper tooth of a big bear or the lower tooth of a small bear," or "We haven't read it carefully enough. He forgot to use a marker so I don't think it would be right."

Willingness to change one's opinion in the face of new evidence is the most advanced attitude of all. The person who has it is tolerant, without prejudice and bigotry. If all the children in the world could really be taught this attitude so that it would function, wars would cease. Science has no monopoly on this attitude, but it offers an excellent opportunity for its natural development. In social studies areas, emotions are more likely to be involved. In solving science problems, children can be more objective. The teacher may say:

"There is a sentence on that page that isn't exactly scientific. Scientists have found out more about it since the book was published."

"When one has the floor, let's remember that others want to talk also, and not take too much time."

"Don't laugh. I'm not surprised that he's mixed up. Grown folks get mixed up, too."

"Do we laugh at people who have ideas?"

"Let John have his chance. Let's listen to what he has to say."
"I think he has an idea, but it just isn't very clear."
"Evidently there are three people who do not agree."
"Jane listened to you; now it is her turn."

Allow every child an opportunity to tell one thing he has observed or learned from an experiment. Give careful consideration to every child's serious question or attempt to explain something. If the teacher respects children as individuals, respects the importance of their problems, and is willing to change her own mind when she sees that she is wrong, it will help in teaching this attitude.

The child who has this attitude will say, "I don't quite agree with her because I think there is a change in the temperature of the land," or "I thought the candle wick burned, but now I know that it is the gas that burns."

Children often have pretty definite ideas about their experiences and are not willing to change those ideas. For example, many people use widely advertised products in their homes without investigating their true value. One science group made a study of some of these products and discovered that the advertising was misleading. The children in the group were learning to evaluate and test statements in the light of evidence.

Willingness to change opinion, to search for the whole truth, and to base judgment on fact are all closely related and may be developed together. They may all result from a comparison of experimental data or accurate observations.

A child may have formed some incorrect idea that he has heard or read in a book. For example, a child insisted that "beavers carry mud on their tails" because he had read it in a children's storybook. The other children challenged his statement. The teacher asked how they could know whether or not the statement was correct. The children said to ask a scientist or look it up in several books written by scientists who had studied beavers. When this was done, the child who had made the statement saw that his idea was wrong. He also realized that he could not believe everything he read.

Although the information and skills needed by teachers for teaching problem solving to children are presented at considerable length on pages 11–18 in each of the Primary Manuals for The How and Why Science Series, an examination of an actual lesson may be of value here.

One of the most difficult techniques for a teacher to master is that of motivation or "problem setting." The ideal way for problems to arise is through spontaneous questions from the children, but this seldom happens until children are well into the science program. Often the teacher must arouse interest and bring to the surface the questions which may be in a child's mind. The skillful teacher can do this in such a natural way that it is not superimposing a topic for study but guiding the thinking of the children. The secret of gaining whole-hearted cooperation in the solution of a problem often lies in this technique. An example of a motivation and exploration period followed by the techniques used in solving a fourth-grade problem will illustrate this.

These fourth-grade children had been studying magnets and were ready for some work with electricity. The teacher asked the children to think of ways in which electricity is important to them. She asked, "How many things that use electricity do you have in your homes?" As the children responded, the list was written on the blackboard. The list stimulated some discussion. Sammy said, "When you rub your feet on the rug you get electricity." Some of the children said that they didn't think it was electricity that he was talking about. Jane said, "You can't run anything with it." Had Jane not made this comment the teacher might have asked, "Can you run a sweeper with it, Sammy?"

Sammy defended his statement by saying that he sometimes got a shock and saw a blue spark. Several children had explanations for these happenings so at the peak of the discussion the teacher asked, "Are you being scientific? You are all giving your opinions but I wonder if that is the way a scientist would settle a question." Since by this time all of the class was interested and ready to state problems, these were listed and written on the board. Some of the questions were:

1. What makes a shock and a spark when you walk across a rug and touch something like a doorknob?
2. Why does the radio go off when you drive under a bridge?
3. What causes static on the radio?
4. What makes telephone wires hum?
5. How does water make electricity?
6. How does electricity make a light go on and off?

The class read the problems and decided to start with:

PROBLEM: What causes the shock when you walk across a rug and touch something?

ANALYSIS:

The teacher directed the analysis of the problem with questions like: "Do you always get a shock when you walk across the floor?" Several children were allowed to demonstrate. Nothing happened. Reasons were suggested, such as: there was no rug on the floor; they didn't scrape their feet. Bob said that he had walked across a bare floor and "made" electricity and that he could do it again. He was asked to try it and was puzzled when he got no results. Since it was a rainy day the teacher suspected that the moisture in the air was responsible, but she merely said, "It is time for us to end our science lesson today. Why don't all of you try the experiment at home tonight on a rug?"

The next day the rain had ceased and the air was crisp and cool. The children had repeated the experiment at home and were ready to report results. Some had managed to get a slight shock, some had not. However, they were ready to give some possible solutions to the problem.

POSSIBLE SOLUTIONS:

Perhaps the temperature causes the shock when you rub your feet very hard on the rug.

Perhaps you and the metal you touch act as two poles which have an attraction for each other. (This idea grew out of their experiences with magnets.)

Perhaps the shock is caused by friction.

As each of these possible answers to the problem was given, it

was discussed to make sure that the child wasn't repeating words he had heard, without understanding them. For example, the teacher asked, "Do you know what friction means?" The child who had used the word said, "Oh yes. It means something strange and wonderful—you know, stranger than friction."

Obviously the word needed clarification. Other answers were: "I think friction is a kind of electricity." "I think friction is like a spark or shock." Finally a child said, "I looked up friction in the dictionary and it said 'rubbing two things together.' "

These answers are given to impress the importance of word meanings. Teachers know that it is essential for children to connect the correct concept with a printed symbol when reading. In a science class, unless all members have the same concept of a word used in discussion, accurate conclusions cannot be drawn. The illustration of the child who confused friction with fiction shows how he could give a seemingly correct answer and still have an incorrect idea.

Having given possible solutions, the children discussed ways of testing them. They thought of experimenting and reading. At this point the teacher remarked that she knew of some experiments in THE HOW AND WHY CLUB which might help.

SOLUTION:

The children read page 315 and the first three paragraphs of page 316 of THE HOW AND WHY CLUB. The experiment suggested others to them and they did the following:

1. Rubbed a pen on woolen clothing and held it near bits of paper.
2. Repeated the experiment with various objects, such as combs, pencils, and rulers.
3. Rubbed pieces of paper on their desks.
4. The teacher suggested the following:

A piece of glass was placed between two books so that the center of the glass was about one half inch from the table. Bits of paper were scattered on the table below the glass. The top surface of the glass was rubbed briskly but lightly with a piece of silk. (If it is rubbed too hard, the experiment may not work.)

Results:

Some exclaimed, "The paper sticks to the desk!"

Tom said, "I rubbed two pieces of paper together and they stuck together. When I pulled them apart they crackled."

Ruth said, "I'm not sure, but maybe when you rub something fast and hard it gets hot. Is that friction?"

Jack asked, "When you rub a balloon on the floor and stick it against the wall, what makes it stay?"

These illustrate the thinking done by children when they are allowed to experiment freely and to express their reactions.

During this period the teacher listened, counterquestioned, and helped children who were having difficulties. When she saw that the activity had accomplished its purpose, she said, "May I have your attention, please?" Then she asked, "What did you find out?" Every child who had something to say was allowed to report on his results before the teacher asked for a summary by saying, "Can someone put everything you have said into a few good sentences?" These were given and written on the blackboard:

What Happened:

When we rubbed a pen or comb on woolen cloth, it picked up pieces of paper.

When a pencil was rubbed on wool, it did not pick up the paper.

When a piece of paper was rubbed against a desk or blackboard, the paper crackled when it was pulled away.

When a piece of glass was rubbed with silk, the pieces of paper under the glass jumped around. Some of them stuck to the glass.

The teacher asked what they now thought about their possible answers. The class decided that the last one was best. The teacher then suggested that they re-read together pages 315 and 316 of The How and Why Club. (Reading orally clears up any mistaken ideas some children may have received as they read silently.)

Following the reading, the discussion brought out the following conclusions:

Mary said, "I think that friction when you walk across the rug causes you to unconsciously pick up electricity."

Shirley said, "I'm pretty sure it is friction because it said so in the book."

Other children stated similar ideas. These were written in their notebooks:

WHAT WE LEARNED:

> When you rub your feet on a rug, electricity is generated by friction. The electricity travels through your body and attracts electricity from whatever you touch. The electricity gives you a little shock.

Had this been an older group of children, each one would have been allowed to write the conclusion in his own words but since these children were just learning to write the steps in problem solving, they gave their ideas orally, then copied the group answer from the blackboard.

A discussion followed of why there is more evidence of static electricity on a cold dry day than on a warm damp one. This is due to the fact that water is an excellent conductor of electricity and the droplets in the air conduct it away as fast as it is generated.

Teachers may contend that this procedure is too time consuming, that the same goal may be accomplished more quickly by reading the text. The author believes that the increased growth in a child's ability to think for himself and the added interest repay the extra time. Over a period of years time is actually saved, since concepts once gained are not forgotten.

The author has taught the same children science from the first grade through the sixth and been amazed to find how much knowledge they accumulated in that time. Very seldom did a concept have to be re-taught. When it was reviewed, though some children seemed not to remember, the others did and it was recalled quickly by the whole group. When no one remembered, the teacher knew that the children had not developed the understanding of the concept in the first place, perhaps because it was too difficult for the age level or because it was poorly presented. More important, through the methods used, the children were independent in their thinking and enthusiastic in their attitudes toward science material.

The following lessons illustrate other types of activities used in solving science problems.

Problem Solving Lesson—Grade 5

Using observation and experimentation

The children knew that a young porcupine had been brought to the science room before they came to class, so all eyes were turned toward the cage and there was a buzz of private discussions and occasional distinguishable tones of disagreement as the children found their places.

Teacher: "What is in the cage?"

Child: "A porcupine."

For a few minutes the children told of experiences they or their friends had had with porcupines. Conflicting points of view brought up the question of how the quills were released from the porcupine's body.

I Problem: How do quills get out of the porcupine?

II Analysis:

Question: I have two quills from this porcupine. How do you suppose they got out of his body?

Answers:

1. Maybe the quills were loose and when you got real close he raised them up and they stuck fast to something.
2. Maybe he shot them out.

III Hypotheses:

1. Perhaps the quills stick fast to anything they touch.
2. Perhaps the porcupine shoots out his quills.

The first two possible solutions were suggested and tested. Neither solved the problem, so teacher and pupils discussed the scientific method to be used when hypotheses first suggested fail to solve a problem.

They decided some additional possible answers must be suggested. The teacher helped the children in their thinking by asking them to think of experiences dogs have with porcupines. From an account of a dog's chasing a porcupine and snapping at it the children formed these hypotheses:

3. Maybe it takes pressure for the quills to stick fast.
4. Perhaps the porcupine has to be frightened before the quills will stick fast.

IV SOLUTION:

A. Gathering Data:

Materials used: Shingle with strip of cloth wrapped around it near one end, rubber gloves, stick for prod.

Teacher: Have you any suggestions as to how we may solve the problem?

Children: 1. Read.
2. Ask someone who knows.
3. Experiment (try something).

Experiments:

1. A child touched the porcupine with a stick.
2. The teacher touched the porcupine with rubber gloves on her hands.
3. The children watched the porcupine when he was frightened by noise and a prod.
4. A boy pressed the stick wrapped with cloth against the porcupine's back.

B. Results:

1–2. The quills did not stick to the board or the glove.
3. The porcupine did not shoot any quills.
4. Quills stuck to the stick wrapped with cloth.

V CONCLUSION:

Quills stick fast to a soft object if pressure is used.

The teacher wrote each step of the problem solving on the blackboard as it was given under the headings: Problem, Suggested Answers, What We Did, What Happened, and Conclusion. As a number of the children were not familiar with the problem-solving method, the teacher asked that each copy the material from the board for their own notebooks.

To confirm their conclusions, the children read page 85 of HOW AND WHY EXPERIMENTS.

I Problem: Why are sandstones different colors?

II Analysis:

Teacher's question: "What colors are sandstones?"
Children's answer: "Sandstones are mostly white and red, but I don't know why."

III Hypotheses:

1. Perhaps the sun has something to do with the colors.
2. Perhaps the sand that the rock was made of was different colors.
3. Perhaps the color was caused by what sticks it together.

IV Solution:

A. First Experiment
   1. Gathering data
      a. The children put different kinds of soil and crushed rock into jars of water, shook them well, and placed them on the window sill to settle.
         (1) Jimmy ground red sandstone and put it into his jar.
         (2) Gertrude used white sandstone.
      b. The next day the children brought different colored sandstones which they had crushed at home.
   2. Results
      a. The next day the children looked at the jars of crushed rock and noticed several things about them.
         (1) The material appeared in layers.
            (*a*) The coarser material was on the bottom.
            (*b*) The finer, sticky material was on top.
            (*c*) There was loose material on top of the water.
         (2) The material seemed to be different colors in some places. Each child showed his own experiment to the class and pointed out what he noticed about it. The class discussed why sandstone might be different colors.

B. Second Activity

1. Gathering data

   a. The next day Walter brought a rock which his grandfather said contained iron. The class discussed possible reasons why the rock might contain iron.

2. Results

   a. Walter brought out his rock that had been standing in water and the class looked at it and discussed the change.

   (1) Some of the rock had come off and made orange-colored sediment on the bottom of the pan.

   (2) The question, "What is rust?" arose. Many of the children gave examples of how iron had been left out in the rain and had rusted, or of different implements that had rusted.

   (3) The teacher then asked, "Does anyone see any connection between the color of rocks and rust?" One child answered, "Sandstone has some iron in it and it rusts. That's what makes it colored."

V CONCLUSION:

A. The cement sticking the sandstone together makes it colored.

1. The cement part may have come from iron ore.
2. The cement may be made of clay which is found in different colors.
3. When we looked through the microscope the sandstone didn't have any color, therefore it must be the cement part that gives the color.

The children read pages 163 and 164 in HOW AND WHY DISCOVERIES to confirm their conclusions.

Written by a fifth grade child

PROBLEM: What makes the sky blue?

POSSIBLE ANSWERS:

The sun hitting the moisture in the air may make the sky blue.
The sun shining on the dust in the air may make the sky blue.
Perhaps there is so much air that when we look through it the sky looks blue.
Perhaps it is because the sky is so far away.

WHAT WE DID:

Gilbert took a paper and put it in a sunbeam. He followed the beam with the paper. He put chalk dust in the sunbeam.
We put a prism in a sunbeam.

WHAT HAPPENED:

We could see the sunbeam shining on the paper.
We could see the sunbeam reflected on the dust.
The sunbeam going through the prism split into colors.

WHAT WE LEARNED:

The dust in the air acts as little prisms and splits the light into colors. Usually in the middle of the day only the blue gets to our eyes. The other colors shoot off into space. At different times different colors show, but most of the time it shows blue.

HOW TO DO AN EXPERIMENT

The purpose of an experiment is to help in the solution of a problem. To be a real experiment it should originate with the persons who raise the question and be carried out by them. Since children do not often have the background to do this, they need help in directing their thinking. However, an activity suggested by the book or the teacher should help solve a problem. Too frequently teachers use a spectacular demonstration merely to get or keep the attention of the children and label it an experiment. While such an activity may be legitimately used once in a while it should not be called an experiment. It is a motivating activity.

If children have a problem to be solved they may learn the experimental technique no matter how simple the problem. Allow them to perform original experiments.

The first step in scientific method is the defining of the problem. The teacher should make sure that the children know what their problem is. It may be as simple as, "Why does a piece of wood float?"—a problem which may arise in any grade.

The next step is the analysis of the problem. The teacher must lead in this analysis by her questioning. She may ask, "How do you know that wood floats?" "What other things float?" "Can you think of ways we might find out why things float?" The children may suggest trying to float several things in water.

The next step is assembling of the materials needed for the experiment. In this case these are a tub of water, various articles such as a sponge, a rock, a cork, some wood, and a balloon. The children should suggest what they think is going to happen before they put the various articles into water. As they work the children will discover that the sponge floats until the holes are filled with water. As this happens air will escape into the water. The balloon will float unless the air is replaced with water. If the balloon is squeezed under water air bubbles will come to the surface as the balloon fills with water. The teacher must be sure that the children observe *carefully* and report *accurately* what happens. She must be sure to give them enough experiences upon which to base conclusions. By having several groups doing the same experiment the children will learn to check their results with those of others. The final check should be with an authority.

Teachers who are helping children to perform experiments will find that careful planning will eliminate confusion. In her plan the following steps will produce better results.

1. Write down the problem to be solved.
2. List the activities to be used in its solution.
3. Select the first experiment to be done.
4. List the materials needed.
5. Note any precautions to be used such as having a metal tray under a burner, or having soda or ammonia ready to counteract acid burns.

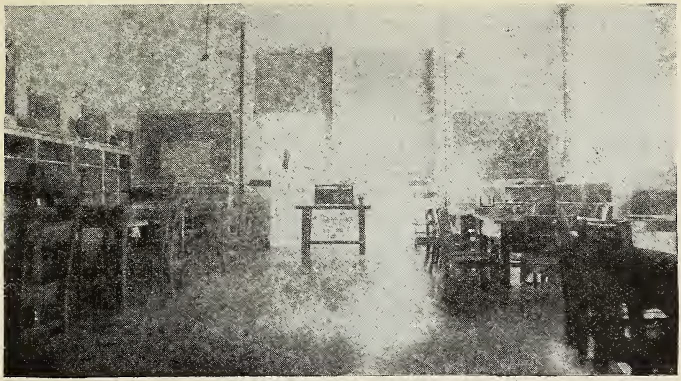
6. List the steps of the experiment in order of procedure.
7. Do the experiment yourself to familiarize yourself with the apparatus and procedure.
8. Jot down exactly how the children will be directed.

To avoid accidents the children should know and use safety measures. Before doing an experiment involving any danger, the children should discuss it and decide what to do in case there is an accident. A first aid kit should always be at hand and any accident used to teach first aid. The teacher should always try to anticipate anything which might happen and to teach the children how to avoid accidents.

Some of the common causes of accidents are careless handling of fire, acids, glassware, hot liquids, and poisonous chemicals. Even experienced teachers may become so interested in the experiment that they fail to notice such possible dangers as a child with long hair bending over a flame or a piece of paper placed too close to a fire. Acids should be handled carefully. The cork from an acid bottle should be held between the fingers with the acid-coated end away from the hand while the acid is being used and replaced in the bottle when one is through using it. Avoid touching clothing or skin with the end of the cork that has been in the bottle. Do not allow children to come too near liquids that are being heated because boiling liquids may sputter, splatter, and pop into their faces. Children should be taught to handle glassware with caution, to avoid being cut.

Warn children to keep fingers and other objects out of their mouths as this may be a means of carrying poisons to their mouths.

In some school systems there are rules against using fire or chemicals in the classroom. In these places teachers will have to substitute an electric plate for heat and use harmless substances such as vinegar and soda instead of hydrochloric acid and calcium carbonate. In most cases it is wiser to use simple chemicals anyway. Too often children have the idea that chemicals and chemical change are confined to the laboratory and do not realize that chemicals are common in their everyday lives.



A science room.

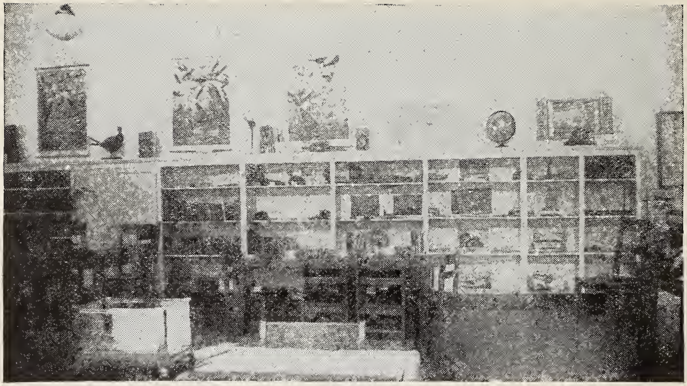
SCIENCE ACTIVITIES COMMON TO ALL GRADES

THE EQUIPMENT OF THE SCIENCE ROOM

Although it isn't absolutely necessary to have a separate science room for elementary science, it is often desirable. The room need not contain elaborate or expensive furniture and equipment. Many times it will be advisable to carry out the science activities in the children's own home rooms. Many schools have a science room where equipment may be stored and where live plants and animals may be kept.

The ideal room is located on a sunny side of the building with plenty of light for growing things. If the room is planned before the building is constructed a small conservatory may be provided in a large bay window with glass doors between it and the main room. Thus the temperature may be kept right for any living things with which the children may experiment.

An ordinary classroom may be adapted to the needs of a science class with very little expense. Water, gas, and electric outlets should be provided if possible. Shelves for books, specimens, and



Shelves provide places for permanent collections.

plants may be installed under windows and cabinets. A closet and built-in cabinets are needed for care of equipment. Bulletin boards and a blackboard are indispensable if classes are to be held in the room. Movable tables and chairs are preferable to desks. The tables should have a hard finish that is washable and not easily marred. Linoleum or newspapers may be used on ordinary tables to protect the tops.

Much of the equipment of the room may be made by the teacher and children with the help of the shop or manual arts teacher. Aquaria of varying sizes may be made or purchased at little expense. See the suggestions in another part of this manual for making and balancing aquaria.

Cages for small animals may be easily made of wire netting and crates. Insect cages and brooding cages are simple to construct.

Some source of heat is necessary such as gas, electricity, or an alcohol lamp. If you have gas, you will need a bunsen burner, a tripod, some wire screening, and a metal tray on which to work.

Jars and bottles of various sizes may be collected to use in place of the flasks, beakers, and test tubes shown in the texts. Pint salad dressing jars are a very useful size.

Coffee cans may be used for many experiments. Waxed paper cups are also useful pieces of equipment.

A compound microscope and a dozen reading glasses 2½″ or 3″ in diameter should be available.

A file to hold pictures and other bulletin board material is a great help. A substitute may be made of an orange crate.

Reference books, science texts, magazines, and pictures should be kept where the children can obtain them easily.

Since one of the habits we wish to have children gain is caring for equipment, dishpans, soap, and other materials should be provided for keeping things clean. Laboratory assistants may be appointed at intervals to help in preparing for and cleaning up after experiments and demonstrations.

A set of Audubon charts, a globe, a good map of the western hemisphere, and a sky chart all help in answering questions. A lantern and slides will also help.

Some dry cells, insulated copper wires, and magnets will be needed for any work with electricity or magnetism. Old switches, fuses, sockets, and other illustrative materials are easily obtained.

The combined ingenuity of the teacher and children should make it possible to collect the materials suggested in the activities or to find substitutes. While some schools have excellent equipment and well planned rooms in which science is taught, equally good teaching is being done in other schools without such advantages. Since science on the elementary level should grow out of the children's own experiences, the very materials that stimulate the questions will provide the answers. The really necessary factors are an alert, interested teacher, normal inquisitive children, and the environment. Below is a list of materials which may be collected from the environment.

Glassware

Salad dressing jars—straight sided and flask shaped.
Fruit jars.
Vinegar and pickle bottles.
Tall, straight bottles.
Different sized pieces of glass cut from broken windowpanes and windshield glass.
Tumblers.
Glass or china saucers.
Milk bottles.
Small-necked bottles.
Lamp chimneys.
Glass tubing.
Pipettes (medicine droppers).

Miscellaneous Equipment

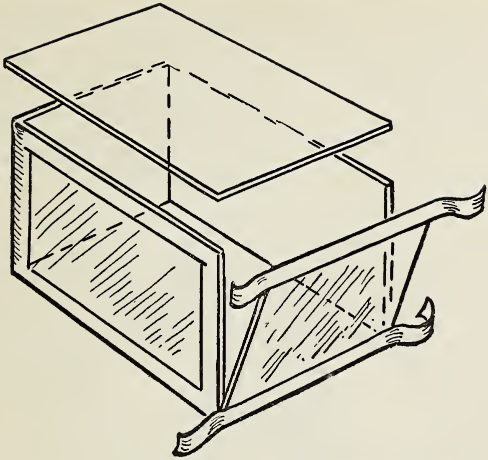
Flower pots.
Tin cups.
Spoons of different sizes.
Knives such as old butcher, paring, and case knives.
Pans that have been discarded to be used to carry snow, heat water, etc.
Pieces of wire screening, scraps of sheet metal, such as copper, zinc, and iron.
Toy balloons.
Cellophane.
Rubber bands.
Scissors.
Scraps of rubber sheeting.
Old balls of various sizes.
Cardboard boxes and cartons.
Chalk and other wooden boxes.
Wire—steel and copper.
Flashlight.
Dry cells.
Empty syrup and oil cans.
Corks of different sizes.
Dry cells.
Hard rubber comb, pen, or other object to use for static electricity.
Simple machines, such as egg beaters, can opener, and hammer.
Nails, tacks, screws, and bolts.

Supplies

Matches and candles.
Starch, sugar, salt, soda.
Vinegar.
Ammonia.
Rubbing alcohol.
Lime for limewater.
Iodine.
Litmus paper, red and blue.
HCl.
Charcoal.

HOW TO MAKE A TERRARIUM

A simple terrarium has so many uses that it is well to know how to make one. First, it is necessary to have a container. A glass jar of any kind will do, but one with straight sides is better than a round one. A glass box may be easily made from six pieces of window glass cut to the desired size. These may be fastened together with one-inch adhesive tape or black *passe partout* tape. Rub the tape until it sticks firmly to the glass. The lid may be fastened so that it is hinged, or merely laid across the top. All edges should be bound with tape to prevent cut fingers. A further precaution is to have the edges of the glass beveled at the time it is being cut.



A terrarium made from glass and adhesive tape.

A wooden base instead of a glass one may be used for the box. If wood is used, it should be so cut that at least one inch will project from around the glass at the bottom. The board may be treated with melted paraffin to make it resistant to water. A half-inch furrow should be sawed in the wooden base, the dimensions of the glass, and made wide enough to take the glass. The glass sides can be more firmly secured in the furrow by means of aquarium cement or putty. Adhesive tape may be put around the top to make smooth edges.

Having a container, start making the terrarium by putting a layer of gravel in the bottom, to provide drainage. Small pieces of charcoal will help keep it sweet. On top of the gravel put soil of the kind found where the plants grow which are to be used in the terrarium. For example, moss and ferns come from the woods. Use woods soil, or leaf mold, for a woods terrarium. Use garden loam for a garden terrarium. Use sand for a desert terrarium.

In the soil plant the moss, ferns, or other plants you wish to use. If you are going to put plant-eating animals into the terrarium, some of these food plants should be planted. For example, if

Making a terrarium for a garter snake.

making a home for grasshoppers, plant corn or oats and let it sprout before putting in the insects. For toads, use garden soil, a dish of water sunk into it, with perhaps some stones and a little grass. The toad will bury itself in the soil. Salamanders like moist moss and pieces of decaying wood under which to bury themselves. Lizards and horned toads will bury themselves in the sand of a desert terrarium.

The terrarium should be kept out of strong sunlight and in a place that is not too warm. It should be sprinkled with water when first made, if it has plants in it. After that it should be sprinkled only when the cover gets dry on the underside. Water should be kept in a dish if there are animals in the terrarium. Snakes go into water, and a tall container like a pint milk bottle or pickle jar of water will make them comfortable. A low dish is better for turtles and toads. This can be placed in one end of the

terrarium and stones and soil built up around it to the level of the top of the dish.

A single terrarium should not contain a large variety of animals. Since boxes of glass and adhesive tape are practical and inexpensive, it is better to have several, each one containing a different kind of animal. Gallon coffee jars make good containers.

A woods terrarium.

The food of frogs and toads in the wild state consists of insects, worms, caterpillars, snails, and slugs. They also eat flies, mosquitoes, and gnats. These can be easily provided, but they should always be alive. Frogs and toads will not touch dead worms or insects. They will starve in a terrarium if they have no live food to eat. A fly trap can be made and once a day the flies released from the trap into the terrarium. When there are insects out of doors, they may be caught by sweeping the grass with an insect net. In winter when flies are scarce, meal worms (the larvae of beetles), which can be cultivated in bran flour, may be substituted.

Newts and salamanders can be fed on bits of raw meat, fish, oysters, scrambled eggs, worms, or insects. Land turtles are plant-eaters, using tender plants and berries for food. Water turtles are meat-eaters, using earthworms, insects, crayfish, and small fish for food. Mud turtles eat under water. Horned toads eat living insects. Garter snakes eat earthworms, insects, frogs,

salamanders, and toads. Snails are vegetarians; lettuce is a good food for them.

Care should be taken that an excess of uneaten food does not remain in a terrarium. Terrariums should be kept clean so that the captive animals may live in healthful conditions.

HOW TO MAKE AN AQUARIUM

Almost any container that holds water may be used for an aquarium, but a straight-sided one is best. The globe-shaped ones afford too little water surface for the absorption of air and they distort the shape of objects inside the aquarium.

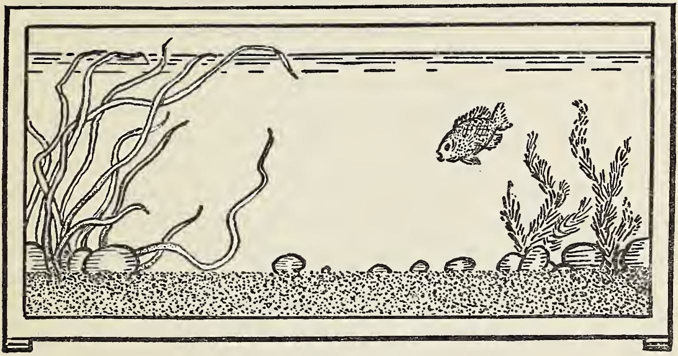
The container must be very clean, and the sand must be thoroughly washed. Sand may be washed by running a stream of water into the pan of sand until the water runs out clean. If the sand is then baked in an oven, any bacteria or mold spores will be killed.

Enough sand should be put into the bottom of the aquarium to insure a good root-hold for the plants. Elodea, eelgrass, and water milfoil are all good aquarium plants and are common in most of our fresh-water lakes and streams. These are satisfactory for summer aquariums but they do not always survive the winter. There are many inexpensive tropical water plants which can be used. Such varieties as Valisneria, Cabomba, Myriophyllum, and Sagittarium are commonly obtainable. It is believed that Valisneria is the best oxygenating plant. This is a grasslike plant which grows very quickly. Duckweed is a small leaflife plant that is often found floating on ponds. It is attractive in an aquarium, though it doesn't help to supply much oxygen.

The plants should be planted in the sand, then anchored with stones. Water can be poured into the aquarium without disturbing the plants by putting a piece of paper on the sand and pouring the water on the paper, or a dish may be placed on the sand into which the water can be poured.

Clean pond, lake, or rain water is best for an aquarium because it contains minute organisms that may later feed the animals. If tap water must be used, allow it to stand several days before putting it into the aquarium. This allows any lime that might spoil

the sides of the aquarium to be deposited and frees the water from any chlorine that has been added for purification. After adding the water, allow the plants time to become rooted before putting



A simple aquarium.

in the fish or tadpoles. Otherwise the animals may pull up the plants.

One rule for the number of fish in an aquarium is one three-inch fish to a gallon of water. Another rule is an inch of fish for each 20 square inches of water surface at the top. Most people are inclined to put more fish into an aquarium than the amount of water justifies.

Any kind of aquarium fish such as goldfish or tropical fish may be put into an aquarium. However, tropical fish are more difficult to keep than goldfish, and require more attention. The water temperature must be kept above 65° for tropicals, and the feeding must be more regular.

Of the tropical fish, guppies, swordtails, and paradise fish survive well and they have interesting habits. Guppies and swordtails are livebearers. Under favorable conditions, guppies reproduce every six weeks. The bubble-nests of the paradise fish are interesting. Tropical fish and goldfish should not be put together in an aquarium as tropical fish often kill the goldfish. Also the fighting paradise fish must be kept away from other tropical fish.

Some wild fish will survive in an aquarium and they make in-

teresting pets. Small sunfish, bluegills, and bullheads are examples.

Snails should be put into the aquarium to act as scavengers. They help keep the sides of the aquarium clean. Tadpoles will serve the same purpose. Clams also help keep the water clean. If water turtles and small frogs are put into an aquarium, they should be provided with flat pieces of wood onto which they can crawl and get out of the water for air.

The first rule in the feeding of fish is not to overfeed. Only a small amount of food should be given, or as much as will be consumed at that feeding. Food not eaten at once falls to the bottom of the container, sours, and makes the water impure. Goldfish can be fed as seldom as once a week. They should not be fed more than three times a week. Tropical fish should be fed three times weekly. A long glass tube may be used to remove bits of uneaten food. Place the tube straight down over the particle, close the upper end of the tube with a finger, and lift out.

Oatmeal (cooked), boiled white of egg, cream of wheat (cooked), liver (cooked), beef (cooked or raw), chopped earthworms, and flies are good food for both goldfish and tropicals. These foods are better than artificial food. Wild fish can usually be fed earthworms or chopped raw beef. They will also eat live insects placed on the surface of the water.

If the aquarium is balanced, the animals and plants will look healthy and the water will be clear. Cloudy or milky water is probably due to the spoiling of uneaten food, or to decaying plants. This water is bad for fish. Immediately remove the fish and clean the aquarium and replenish with fresh water. In changing fish from one container to another, keep water temperatures the same. Fish cannot stand sudden changes of temperature. Be sure also that tap water has been properly conditioned to remove chlorine. Allow it to stand for twenty-four hours before putting it into the aquarium.

Fish should be handled with a small net or lifted out in a dish of water. Grasping them with the hands is likely to break the film over the scales and permit fungus to get started. If a fish is diseased, remove it at once and put it into a solution of salt water, in proportions of one teaspoon of salt to a quart of water. It may remain in the solution for a period of several hours. Then put it

into a container of fresh water. Repeat the treatment every day until the fish is well.

The children will get much pleasure and profit from their management of both terraria and aquaria. There are many interesting aquarium books and magazines on the market to which they can turn for lists of animals and plants and for notes on feeding. Also in recent years there has been much interest in amateur tropical fish raising and many of the children may come from homes where there is a tropical fish enthusiast.

HOW TO CARE FOR CATERPILLARS

Some caterpillars spin cocoons, some form chrysalids, some go into the ground to pupate, some spend the winter hibernating in the larval stage. In discussing them with the children, suggest that since the caterpillars they find may not be ready to pupate, they must be sure to bring in some of the leaves on which they find the larvae. Then you will know what to feed them. Caterpillars will leave food and hunt a suitable place when they are ready to pupate. Polyphemus caterpillars may be put into a glass jar that has some twigs with leaves on them. A piece of glass may be laid over the top of the jar. This prevents escape of the caterpillar and also helps keep the leaves fresh. If the caterpillar is still hungry it will eat the leaves. The jar should be cleaned each day and fresh leaves put into it. When the caterpillar is ready to spin, it will use the twigs and sides of the jar as its foundation and spin leaves into its cocoon. When the cocoon is finished, it may be removed from the jar and put into a cool place until spring. Jar and all may be put away. If it is kept in a dry place, the cocoon should be dipped in water once in a while.

Caterpillars like the tomato sphinx (tomato worm) go into the ground to pupate. There should be some garden soil in the bottom of the jar for them. A flower pot with a cylinder of wire screening over it is good, also. Some Woolly Bears hibernate in the larval stage so a terrarium with some dead leaves and pieces of bark makes a good home for them. They will spin in the spring. Some Woolly Bears spin in the autumn.

The Monarch or milkweed caterpillar forms a chrysalis. If the children bring any Monarch caterpillars in, put them into a jar

with milkweed leaves. When ready to pupate, they will spin pads of silk on the underside of a jar lid, leaf, or twig, then hang from it and shed the larval skin, leaving the green chrysalis. Since the caterpillars that form chrysalids in the autumn soon emerge, they may be left in the room for the children to watch. Chrysalids of butterflies that emerge in the spring may be cared for in the same way as the cocoons.

Fruit and salad dressing jars are just as good as more elaborate equipment. The main things to keep in mind are to have fresh leaves of the right kind which are kept from drying too quickly but are not wet, and not to have too much heat. After pupae are formed, they should be placed in a cool place, not moist enough to mold, but not dry enough to kill the pupae. Cleanliness in their care is important, as many caterpillars are susceptible to disease. Also when handling caterpillars, be careful not to bruise them. It is better to let them crawl onto a twig and then move the twig, than to pick them up with your hands.

OTHER ANIMALS IN THE SCIENCE ROOM

The extent to which it may be desirable to keep animals in a schoolroom depends upon the size and facilities of the room, the interests of the children, and the kinds of animals you wish to keep. While some plants and animals if properly cared for are sure to make a room more interesting, we mustn't lost sight of the fact that the children are the most important occupants of the room. If having other animals makes the room less attractive or comfortable for the children, you should either do without the other animals, or choose animals that are easily kept in captivity and cared for.

Directions for the care of aquarium and terrarium animals have already been given. All these cold-blooded animals are clean in their habits and have little or no odor about them.

Small mammals such as rats, mice, guinea pigs, and rabbits may be kept in cages in the room if the cages are kept clean. Cages with removable metal bottoms are more easily cleaned than wooden ones. A cage may be made of an orange crate with a galvanized iron tray made to slide in the bottom of the box. One-

Observing a turtle.

half-inch mesh galvanized wire should be fastened to the open side and a sheltered corner should be made of a smaller box which is placed inside the cage. All animals need to have a place in which to hide.

Sawdust or straw should cover the floor of the cage and be replaced with fresh material every day. If a layer of newspaper is put on the floor first, the cage can be more easily cleaned. The animal will carry some of the material into its sheltered corner.

Guinea pigs and white rats are more easily kept in a schoolroom than rabbits. Rabbits may be brought in for a day or two, but it is better for them to live out of doors.

These rodents may be fed oats, alfalfa hay, carrots, and other vegetables. The young ones should have milk and a few drops of cod liver oil each day during the time when they do not get plenty of sunshine. Evaporated milk diluted with warm water is more easily digested by these small mammals than is fresh milk.

If the schoolroom is closed and becomes either very hot or cold over the week-ends, the animals should be taken to the home of one of the children. Extremes of temperature are not good for warm-blooded animals, particularly when in captivity where they can't protect themselves.

Although many of these animals are able to get their water from

Feeding a young squirrel.

their food, water should always be provided in the cages. The container should be low enough for the animal to drink from and of a kind not easily tipped over.

Wild rodents, such as meadow mice, squirrels, and chipmunks are sometimes brought into the schoolroom. Adult wild animals are difficult to tame and often refuse to eat. Young wild rodents, however, may be cared for and make interesting pets. If they are very young they may be fed on warm, diluted evaporated milk. The smaller the animal the more warm water should be added to the milk, the more frequently it should be fed, and the less it should have at each feeding. One needs to use common sense in caring for these young animals. Keep them warm, let them alone as much as possible, and don't overfeed them.

Children sometimes bring other young mammals to school. Until the animal is old enough to eat solid food, its care is the same as for the other animals mentioned above. Teachers may find detailed directions for rearing all kinds of wild animals in Moore's *Wild Pets*. See reference list.

Young birds are easily reared if you know the food to give them. Any good bird book will tell the food of the common species of birds. Insect-eating birds may be fed earthworms, caterpillars, and small larvae of beetles. Hard-boiled eggs may be substituted

for part of their food. The shells should be crushed and fed with the egg. Young flickers may be fed raw eggs and ants.

Seed-eating birds may be fed any kind of small seeds. Chick-feed is easily obtained. Some bread may be given them but should be supplemented with seeds. All birds need sand and other hard foods.

When a bird is first found it may have to be fed forcibly. Open its beak gently and put the food in the back of its throat. A pair of forceps or tweezers is useful in accomplishing this. The bird won't swallow unless the food touches the swallowing center on the back of its tongue.

Fish-eating birds such as bitterns and loons are occasionally found and brought to school. These are problems to feed as they do not thrive on dead fish. The author has successfully fed young fish-eating birds on live tadpoles and minnows.

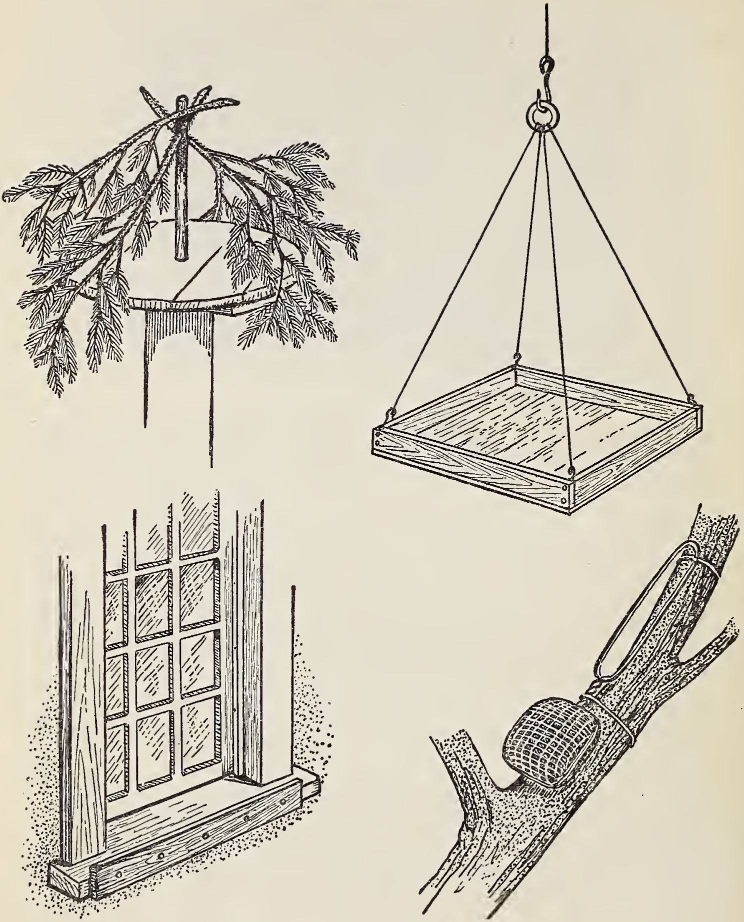
Hawks and owls may be fed pieces of meat which have been wrapped in cotton or rolled in sand. These birds should be handled with care as their bite is painful. Young ones soon learn where their food is coming from and open their mouths.

Unless a wild animal is too young to care for itself, it is wise to keep it awhile for study and then release it. School buildings are not built to house the lower animals. A trip to a well-run zoo will demonstrate how varied are the needs of the different groups of animals. It would be impossible to duplicate these conditions in a room where children live. A cage built outside a window on a level with the window sill will partially solve the problem. If a squirrel or rabbit is to be kept for any length of time this might be worth while.

In caring for any animal, the children should be made to feel responsible. They should read about the natural habitat and food of the animal and try as nearly as possible to duplicate these conditions. Even though some animals die, the value to the children makes caring for them worth while.

WINTER BIRD FEEDING

In the northern part of the United States most of the common birds migrate in the autumn but there are a few that remain through the winter. Why birds migrate is a question no one has



Simple feeding stations for birds.

solved satisfactorily, although there has been much written on the subject. The teacher should familiarize herself with the theories of migration and not try to solve the problem.

Half a coconut may be filled with melted fat.

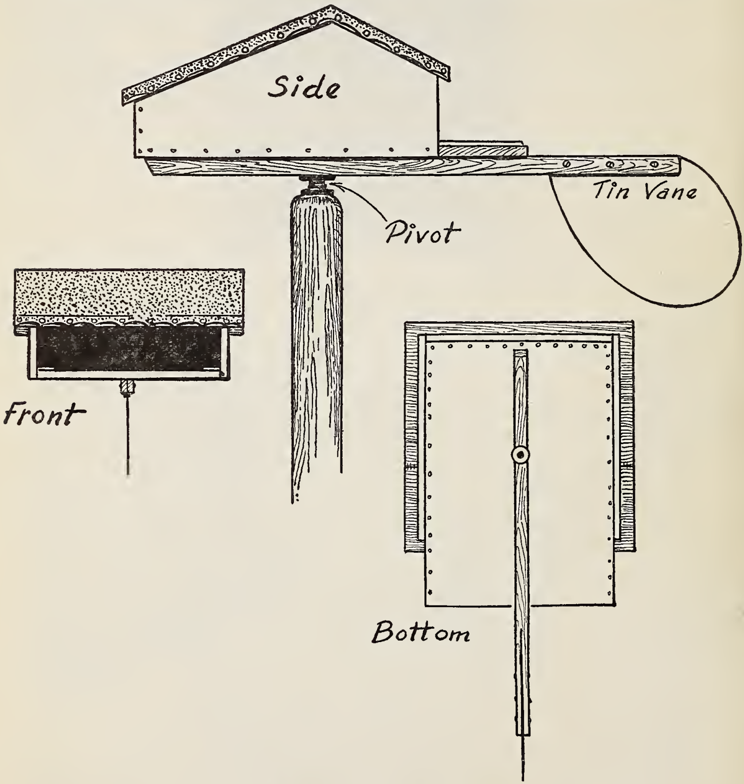
Some winter bird residents stay the year around in the north. Among these are the chickadees, nuthatches, and downy woodpeckers. Others come from farther north, spend the winter, and return to their northern nesting grounds in the spring. Brown creepers, juncoes, and tree sparrows are examples of these.

Some winter birds are insect-eaters and some feed on seeds or fruit. The downy woodpecker is able to chisel through the bark of a tree and with its tongue spear the larvae underneath. Nuthatches and brown creepers get insect eggs and insects from the crevices in the bark. Chickadees and titmice find their insect food mostly in the buds and on the twigs of shrubs or trees. But in winter, all of these will eat whatever they can find. Since they are meat-eaters, we put suet or nuts on the feeding shelf for them. To prevent suet from being carried away by a blue jay or starling, it may be put into a wire basket made of coarse screening.

A soap shaker may be filled with suet and hung from a wire. The suet may be tacked to a tree or tied to a limb. The nuts

should be crushed or finely cracked to prevent squirrels from carrying them away. Birds will scratch among the shells and pick up the bits of nut meats. Walnuts or hickory nuts are good bird food, and may be gathered by the children in the autumn, to save for winter feeding. Half a coconut may be filled with melted fat and hung from a branch. Cracked nuts or seeds may be added to the fat.

Juncoes, sparrows, goldfinches, and cardinals are seed-eaters.



A more elaborate feeding station.

Any seeds, such as wheat, oats, millet, or cracked corn, will attract them. Sweepings from a mill are welcomed by birds and they will scratch in the chaff for days, finding tidbits. Cardinals and grosbeaks are especially fond of sunflower seeds. Crumbs of any kind will attract birds, as will berries and pieces of other fruits. The children can put out discarded apple cores and cranberries. Breakfast food or other cereals which might be discarded because of weevils are good bird food. Even weed seeds are attractive to birds. Dried fruit will attract some birds.

Shrubs with berries on them always attract birds. Among these are snowberry, barberry, high-bush cranberry, wild plum or cherry, and bush honeysuckle. Teachers who have anything to do with landscaping the school grounds should see that some such shrubs are planted.

A simple shelf is as effective as a more elaborate one. Just an extension from the window will work, although a roof prevents snow from covering the food. The birds may not come at first, so a good way to get them started is to sprinkle some grain on the ground under the shelf. The sparrows will come first and though we do not care so much for them, they show the other birds the way. A dry doughnut dangling at the end of a string will provide entertainment equal to circus acrobats. Peanuts fastened to a string stretched across the window or between trees will also attract birds.

A swinging shelf usually frightens sparrows and drives them away. However, for teaching purposes in the primary grades even an English sparrow has possibilities.

In snowy, freezing weather, water is as hard for birds to get as is food, so water should be put out for them each day. It will often attract birds not attracted by food. A shallow earthenware container like the saucer of a flower pot is good for this purpose.

FIELD TRIPS

If properly conducted, a field trip may be an important activity to help in the solving of some science problem. Improperly conducted, it may be a waste of time.

A field trip must have purpose. It must come as a result of a need to learn something outside the schoolroom. It need not mean

A field trip—looking for birds' nests.

a long trip. For example, in a discussion of soil formation the question may arise of whether freezing and thawing break up rock and form soil. To illustrate this, the children may go outdoors and find rocks that have been cracked in this way. Even sidewalks and the foundations of buildings illustrate the point.

The teacher should anticipate any trip she plans and make the trip herself before she takes the children. If she intends taking the children to see birds, she should make sure that there will be birds to see. Birds are elusive and cannot be tagged and made to stay in one place. But a nest that is being built, or the work of a woodpecker located by the teacher or some member of the class, will remain until the whole class sees it. The chances of also seeing the bird will be good. With a definite objective in mind, the teacher is sure to prevent disappointment and aimless looking.

Before starting on a trip, the teacher must be sure that every

A field trip—locating territories of birds.

child knows what he is going to look for. There is endless variety in the number of interesting things to see out of doors, but unless the attention is directed to a few, there will be confusion, and no learning will result.

For example, on the way to a river to see erosion, the group may watch for terraces that have been made as the river cut down to its present bed.

A large group should be organized into small units with a leader for each. These may be working on the same problem or different problems. If unusual things are found, the whole group may be called together to see them.

A simple way to organize groups is to make enough slips of paper for each member of the class. Number them from one to five. Circle one of the number ones, one of the twos, one three,

After a field trip—rock study.

one four, and one five. Have the children draw slips. All the ones make a group. All the twos make a group, and so on. The children with the circled numbers are the leaders for the day.

Children like to make their own rules for field trips and take pride in following them. Here is a set of rules made by a third-grade class before going on a trip to study birds.

1. Walk quietly. No loud talking.
2. Follow your leader.
3. When you see a bird, stop. When the leader stops, everyone stops.
4. When you see a bird and want to show it to the rest of the group, tell them, without pointing, where it is. (Birds see better than they hear and are startled by quick motions.)
5. When you are looking at a bird, stand with your back to the sun.

Too many rules are confusing just as too many directions are. It is better to take short trips at first, trying out one rule; then add more rules as longer trips are taken. If the children understand what the trips are for, they will gain the proper attitudes toward them.

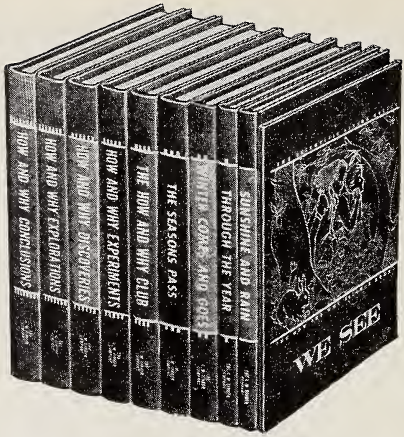
It is very important in any science work to respect the discoveries and ideas of children. When they see or find things on a trip, the group should give as serious attention to them as to the teacher's contributions. This encourages children to observe and it intensifies their interest.

On a collecting trip, enough containers should be taken along to carry back any specimens. Directions on how to collect and what to collect should be clearly understood before leaving the school. Collecting should be done only when material collected is to be used. If such material may be studied to better advantage in the schoolroom than out of doors, it serves a purpose. But only as much as is needed should be taken. Gathering hundreds of frogs' eggs would be wasteful when a few would be all the children could care for. It is better to raise a few tadpoles to adulthood than to have dozens die for lack of room or food.

Some of the types of trips may be listed as follows:

1. A trip to locate territories of birds. Return at regular intervals to watch nest building and rearing of young.
2. A trip to collect rocks.
3. A trip to see types of erosion.
4. A trip to find tracks of animals.
5. A trip to find and collect galls.
6. A trip to a zoo or museum to see something that has been discussed in class, such as fossils.
7. A trip to a meadow to collect weed seeds.
8. A trip to observe the sky.

The suggestions for teachers that are given later in this manual list other ways to give purpose and variety to field trips. Trips should never grow so common or become so regular as to be monotonous, nor so dull as to be meaningless. Children should always regard them with enthusiasm, not because they offer an opportunity for play, but because they are the most satisfying solution to many of their science problems.



THE HOW AND WHY SCIENCE BOOKS

BASIS FOR CHOICE OF MATERIAL

CHILDREN'S INTERESTS

Children's interests were closely studied in preparing and organizing the material used in THE HOW AND WHY SCIENCE BOOKS. The subject matter was used by the authors in actual teaching experiences over a period of several years and with many different age groups of children. The problems were used in mimeographed form until arranged for publication.

RECENT COURSES OF STUDY

The material for the books was originally chosen from units that appeared in many courses of study from many sections of the United States. City and state courses of study were consulted, as well as those prepared and used in teacher-training institutions. More recent studies, problems which have arisen in the classes of the authors, and new courses of study have added new material to the original series.

THE THIRTY-FIRST AND THE FORTY-SIXTH YEARBOOKS

The outlines for science in the elementary grades found in the *Thirty-First Yearbook* and in the *Forty-Sixth Yearbook* of the National Society for the Study of Education have been closely followed. Some quotations from the *Forty-Sixth Yearbook* are of interest here:

"Instruction in science should begin as early as children enter school; activities involving science should be provided even in the pre-school and the kindergarten. Through the sixth grade the work in elementary science should consist of a continuous integrated program of the sort advocated by the *Thirty-First Yearbook*. Such a program should provide an expanding, spiral development of understandings, attitudes, and skills, as prescribed in chapter iii."—pp. 41–42

"It is most important that the material selected for each grade of the primary school be balanced to include the elements of learning which represent a rich experience with science. Each level should give the child some opportunity for exploration with content derived from the great major fields of science: astronomy, biology, geology, and physics. This cannot be accomplished by studying only plants and animals.

"There should also be balanced instruction as to the types of activities employed. Children should have a rich opportunity to develop their abilities in discussion, in experimentation, in observing in the out of doors, and in reading for information and motivation. A complete program of instruction in primary science can be maintained only by the full utilization of all these activities, for each plays its part in the development of the purposes of science education."—p. 84

"Since experimentation involves 'learning by doing,' there can be no substitute for it. Pupil experimentation is an essential part of science education. In every course of science offered at any level, therefore, opportunities should be provided for pupils to perform experiments." —p. 53

"The basic purpose of the elementary school is the development of desirable social behavior. Science, with its dynamic aspects, its insistence upon critical-mindedness and better understanding of the world, and its demand for intelligent planning, has a large contribution to make to the content and method of elementary education.

"To accomplish this basic purpose a continuous program of science instruction should be developed throughout public school education, based upon a recognition of the large ideas and basic principles of science and the elements of the scientific method. Children must be given opportunity to gain the knowledge necessary for intelligent and

cooperative experience with the world of matter, energy, and living things and to develop constructive appreciations, attitudes, and interests. This demands that the individuals in our society become intelligent with reference to the place of science in individual and social life.

"When the content and method of science are examined, it is found that the child's normal activities have much in common with the purposes of science in modern society and that the teacher can view the teaching of science as utilizing the natural dynamic drives and potentialities of children."—p. 73

"Work in the primary grades should not be exhaustive. Rather the child should feel that there is more to learn about everything that he does. A developmental point of view demands that a well-balanced program provide contacts with realities. It cannot allow omissions in the development of the concepts, principles, attitudes, appreciations, and interests derived from the field of science."—p. 82

"The new program of science, which emphasizes the development of desirable social behavior, is organized around problems that have social value and are challenging and worth while to children. The teacher must, therefore, look back of the objects of the universe to the problems which involve meanings that the children will need to understand in order to participate intelligently in life. This means that, in science, opportunities must be provided for the development of understandings in all the areas of the environment and at all levels of social needs."—p. 92

HEALTH, SAFETY, CONSERVATION, AND AERONAUTICS AS INTEGRAL PARTS OF A SCIENCE PROGRAM

The authors of The How and Why Science Series have made health, safety, conservation, and aeronautics integral parts of the science program. This is in accordance with the recommendations of the *Forty-Sixth Yearbook*:

"*What is the place in the science curriculum of conservation, aeronautics, physiology, and health education?* The materials of these areas are of value chiefly for general education. Except, perhaps, for an eighth-grade one-semester course in health and physiology, it is probably not desirable to offer separate courses in any of these subjects. Their materials can be more effectively integrated with those of the regular courses of the science sequence and with other courses in the program of studies."—p. 46

"The content of the science program in many elementary schools is now being organized around problems which have social value and which are significant in the lives of children. These problems arise from children's

interest in the world around them and from their need to meet intelligently their problems of living in areas such as health, conservation, and safety. They are solved not through the mere accumulation of facts but in such a way as to help children (1) develop meanings which are essential to social understanding, and (2) put into practice desirable social behavior. Problems involve meanings in their solution, and meanings are learned through experiences."—pp. 69–70

"A program in science should develop a large background for the teaching of health. Many schools are now integrating health entirely with science and the social studies. Science provides much of the background for the teaching of health facts and the development of health habits. Moreover, in their study of science, pupils should gain a vision of the potentialities of science in the improvement of the health of the nation and the world."—p. 76

"Likewise, science is involved in accident prevention and safety instruction. We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well, then, in safety instruction to place more emphasis upon the scientific principles which are basic to safe conduct."—p. 77

"The place of science in bringing about the wise utilization of natural resources to the welfare of mankind is an important aspect of the science areas related to the social needs."—p. 77

HEALTH

The study of health in our public schools should be an integral part of the science program. To study health without its scientific basis is to leave the study without form or background. This fact can be illustrated by examining almost any phase of the teaching of health. Let's start, for example, with respiration.

We teach that man breathes air. In his lungs the oxygen from this air passes through the walls of the capillaries into the blood. Here because of hemoglobin in the red corpuscles, oxygen is taken with the blood to the heart and then to all parts of the body. The oxygen enters the cells. There it is united with food material that comes through the digestive tract and the blood. The food is oxidized, producing heat and other forms of energy. This is a simple little statement that one might find in a health book. Where does the oxygen come from? What is it like? What are its properties? These are science problems.

Botany teaches us that plants use carbon dioxide in making food and give off oxygen. All green plants do this. This is where part of our supply of oxygen comes from. Chemistry teaches us the properties of oxygen. It also teaches us about oxidation. It is important to know that the uniting of oxygen with other materials forms new chemical combinations. This makes it possible for the student to understand what happens in the human cell when oxidation takes place. He discovers that heat and other forms of energy are produced. In order to understand heat and its relations to other forms of energy one must understand physics. This involves the physical properties of heat, energy, and the passage of energy from one form to another.

Oxidation in the cells produces energy and gives off carbon dioxide. Carbon dioxide dissolves in the blood, is returned to the lungs, and breathed out. The student who reads the story of respiration in a health book given to health must consult botany, chemistry, and physics in order to understand the story intelligently, or the health book must contain much science material.

The student who has studied respiration as taught in the How and Why Books knows the scientific background of every step of the process; hence, he can understand the interrelationship between plants and animals. In fact, respiration becomes an intelligible story. Respiration cannot possibly be taught as an isolated phenomenon. It must be incorporated into a book covering all phases of science to be intelligible.

How does the body grow? It grows through cell reproduction. A student who understands this must understand the meaning of the word *cell.* In science this concept is developed in connection with one-celled animals and plants. The student who knows how a cell divides to form two, and the two further divide to form more cells, and how each cell is composed of a cell wall, protoplasm, and nucleus is ready to understand how the epithelial cells of the skin and mucous membranes divide and grow to cover the body. It would be impossible to teach the concept of human cells without giving a scientific background.

Another example is that of the study of digestion. Digestion begins with food. To understand digestion one must know about the various types of food. One must understand the character-

istics of each kind of food. One must know the unique function that each kind of food has in the body. In science children study these foods. They study the relation of animals to food. They study the relation of energy to food. When they have questions concerning their own digestions, they have an intelligent background of understanding. Let's take an example. A child puts some potato into his mouth. If he has studied the science of plants, he knows that a potato is a tuber. He knows that it is made up of about ninety-five per cent water and some starch. He knows, therefore, that when he starts to chew the mouthful of potato, he mixes it with saliva. He knows that there is a material in saliva which changes starch into sugar. This is a chemical change. The potato passes through the esophagus into the tomach. Here it is further mixed with other digestive juices, and the starch is completely digested into a soluble sugar. This sugar in solution passes through the walls of the intestines by the process of osmosis. What is osmosis? Osmosis is something one learns about in physics. It has to do with the pressure of different fluids and their passage through a membrane. The food travels in the blood to the cells of the body where it goes through the chemical process of oxidation. How would one teach food and digestion if he had to teach it without science? There is nothing in the program of health that can be taught as an isolated fact and be intelligible.

Let's look as muscles. Of course we must teach about muscles. We must know about cells to understand how muscles are made. How do muscles act? In the first place they get their energy by the oxidation of food in the cells. This process cannot be understood unless one understands chemistry. By using the energy produced by oxidation the muscles contract. When the muscles contract, they move the bones. To understand how they move the bones it is necessary to know some physics, because the muscles that move the main structure of the skeleton work on the law of levers as developed in physics. Muscular activity involves the laws of both chemistry and physics.

If we turn to the senses, it would be impossible to even attempt an explanation of how we see without some conception of the physics of light. It would be impossible to understand the use of glasses unless one knows the laws of refraction that are taught in

physics. It would be impossible to know how the eye functions to focus the light on the retina and understand what happens to light waves as they pass through certain types of media. We must have some knowledge of the physics of sound and how the vibrations work to understand how the process of hearing takes place.

Health principles are based on scientific fact. The How and Why Science Books have put the health program in the science field where it belongs. The development of science concepts throughout the books advances the basic health rules logically and naturally.

SAFETY

Safety is taught both in connection with health and as a part of scientific procedure. In the intermediate books of The How and Why Science Series the following concepts contribute to an understanding of principles of safety.

The How and Why Club:

pp.	5	Care in riding bicycles on the highway.
	6–9	Safety regulations at an airport.
	40	Safety in using chemicals.
	80	Recognition of the only poisonous spider in the United States.
	159–174	How to keep food from spoiling.
	176–179	Pasteurization.
	197	How to tell directions at night.
	237–243	Safety in using tools.
	245–247	Protection of the eyes from the sun.
	315	Avoiding danger from lightning.
	324	Use of fuses to prevent fires.

How and Why Experiments:

pp.	26–29	Harmful fungi and bacteria and how to eradicate them.
	89–91	Man's protection against weather.
	112–115	Protection against insects that carry disease.
	116–121	Immunization against diseases.
	167, 168,	170 and wherever fire is used in an experiment. Safety rules for using fire.

	209	How to make and use a fire extinguisher.
	210	How to avoid carbon monoxide poisoning.

How and Why Discoveries:

pp.	42	Use of alcohol on a needle to kill bacteria.
	251–252	How a rescue bell works.
	289–293	How water can be purified.
	305	Use of electrical switches.
	313–315	Protection from electricity.
	355–374	Prevention of disease.

CONSERVATION

Many activities in science may contribute to the objectives of conservation education.

Dr. Ira N. Gabrielson, director of the Fish and Wildlife Service of the U. S. Dept. of Interior, in his book *Wildlife Conservation* says, "the various programs for the conservation of soil, water, forests and wildlife are so closely interwoven that each vitally affects one or more of the others. All are phases of a single problem —that concerned with the restoration and future wise use of our renewable natural resources. . . . The term 'conservation,' when applied to the two classes of renewable and nonrenewable resources, carries quite different meanings. The conservation of the inorganic or nonrenewable resources, such as coal, iron, copper and oil, means sparing use with no waste. The conservation of organic resources implies use, but only to an extent that will permit a continual renewal."

The scientist's concept of conservation has changed in the last few years and broadened to include not only minerals and wild life but human resources as well. It is with this last resource that elementary teachers are most concerned. To conserve human life and well being for future generations, it is particularly important that we take thought today. The children we are teaching are facing a very uncertain world, politically and economically. Someone has said "Our children are living in the world of today, we are not." We need to take stock of our curricula and see whether or not this is true. Are we teaching the things that are vital to the preservation of the race or are we still clinging to the patterns we ourselves were taught to follow? If conservation is vital to the

preservation of man, how can we make it a vital part of our science program?

In the first place we must find natural ways in which the problems of conservation fit into the lives of the particular groups we teach. Suggestions have been given in various places in the intermediate books of the How and Why Science Series for discussing conservation of plants, animals, soil, and water. The ways that arise will depend upon the conservation needs of the region. In one region it might be soil, another game, another water, another forests. In a crowded city district it might be utterly out of place to discuss wild-life conservation with children who lack food and sunshine. Ways and means of helping these children to build strong bodies would obviously be the conservation program needed there.

Teachers need to be careful not to become so enthusiastic about the subject of conservation as to forget that they are teaching children, not subjects. As adults we should be much concerned about the future and its resources. Children cannot and probably should not be confronted with such remote problems. If the best trained men in the country have been able to do little about soil erosion and flood control, certainly children can't attack the problems.

But children can see what rain and melting snows do to their lawns and terraces. They can see the results of malnutrition in other children. Pictures of the children in starving countries continually bring this to mind. They can attack problems of plant and animal interdependence as suggested in various units in the How and Why Science Books. The attitudes, habits, and appreciations gained in these units may be easily made a part of a conservation program.

Concepts contributing to an understanding of conservation are taught in the following chapters of the intermediate books:

The How and Why Club:

pp.	44–59	How Beavers Live
	73–83	A Spider's Bridge
	84–87	More About Spiders
	89–93	Plants Depend on Animals

94–107	Animals Depend on Plants
116–127	Foods the Body Needs
164–174	Why Does Food Spoil?
176–179	Pasteurized Milk
225–235	Weather Changes Rocks and Soil
282–289	Some Drummers

How and Why Experiments:

pp.	5–15	How Weeds Grow and Survive
	30–56	Birds Migrate
	64–76	The Struggle Among Living Things
	102–116	Why Man Destroys Some Insects
	246–255	How Plants and Animals Live Together
	292–302	Use—Don't Waste
	326–335	Feathered Mouse Catchers

How and Why Discoveries:

pp.	193–205	Enemies and Friends of Health
	219–228	Conservation of Wild Life
	284–294	The Importance of Water to Man
	355–372	How Our Health Should Be Safeguarded

AERONAUTICS

Although World War II gave an added importance to the subject of aeronautics, and a considerable number of separate courses in this field are being taught, chiefly in the senior high school, the authors of THE HOW AND WHY SCIENCE SERIES believe that this subject can be more effectively integrated with the regular science course. Beginning in the Pre-Primer, the books of the series provide valuable and adequate instruction about the science of flight. Again, this material takes its place as a part of the science program in the study of air and its properties.

In the intermediate books, the following concepts contribute to an understanding of aeronautics.

The How and Why Club:

pp.	6–16	Airplanes land on special landing fields.
		Airplanes have many safety regulations and devices.

Pilots must obey signals and regulations for their own and their passengers' safety.

Passengers, visitors, and the ground crew must also obey safety regulations.

Weather is one of the most important factors in flying.

A pilot must know the direction and force of wind before landing. He must also know which runway to use.

Red and green lights are used to signal when a plane is to land.

The important parts of an airplane are: propeller, engine, landing gear, fuselage, wings, ailerons, elevator, rudder, nose, and stick.

197 The stars have helped guide aviators to safety.

How and Why Experiments:

pp. 175–177 Four main forces that act upon an airplane are gravity, lift, thrust, and drag.

The force of gravity is overcome by lift.

The wings of an airplane are built so that the pressure on the top of the wing is less than the pressure on the underside. This produces lift.

The force that moves the plane along the ground is thrust.

Drag, the force trying to hold the plane back, is caused by the resistance of the air to the forward movement of the plane.

How and Why Discoveries:

pp. 169 Weather presents many hazards to the aviator.

187 To determine the speed and direction of the wind, weather observers send up a radiosonde consisting of a balloon which carries instruments to measure temperature, pressure, and humidity.

188–189 Air travel is made possible by constant use of weather predictions.

All air travel is controlled by the Civil Aeronau-

tics Administration. No clearance will be given any plane unless the weather report is favorable.

270–279 A balloon will rise when the air inside the balloon is much lighter than the air in the atmosphere surrounding the balloon.

A dirigible is equiped with an engine that drives it forward, and a steering device.

A helicopter is a powered plane with rotating wings connected with the engine.

An autogiro is similar to a helicopter. The engine is connected with a propeller and the rotor is set in motion by the action of the air and the movement of the plane.

A glider is a heavier-than-air craft having no power, no engine, and no propeller. When launched, it is carried by wind currents and updrafts of air.

A parachute is used to check the fall of a jumper.

THE PLAN OF THE INTERMEDIATE SERIES

THE ORGANIZATION OF MATERIAL

The intermediate books of the How and Why Science Series enlarge upon the concepts presented in the primary books and introduce new ones. An effort has been made to show how the simpler concepts contribute to more complex concepts and principles. The material is organized around major problems which might easily grow out of children's questions if properly introduced.

THE SCIENCE CLUB

The idea of a science club as introduced in The How and Why Club may be used to advantage throughout the intermediate grades. A science meeting at the beginning of each class period gives the children an opportunity to relate the experiences they have had outside the classroom. It gives them training in conducting a meeting of their own, and thus contributes to their social development. It helps develop their curiosity concerning their

environment and ability to observe accurately. It gives them an opportunity to ask questions and thus gives the teacher an excellent key to their natural interests.

ILLUSTRATIVE MATERIAL

Environment and individual differences play such an important part in children's science interests that the teacher must be guided by her own group in the choice of problems. Some problems may have to be teacher-motivated because lack of experience on the part of her group may mean that the children will not initiate them. Once introduced to the material, children should accept it with interest, otherwise it is not suitable for them.

Illustrative material should come primarily from the child's own environment, but not exclusively so. In this regard the *Thirty-First Yearbook*, page 148, states:

> "Some have contended that no illustrative material should be used except that which is in the natural environment of the school. This seems to be a very narrow interpretation of illustrative material. In this day when the child listens to the events happening in Antarctica, or other far parts of the earth, in which his environment is spreading out so that the whole world comes into his own home in one way or another, to restrict the illustrative material to local, indigenous objects seems, indeed, to be inexcusable."

THE COMPANION BOOKS

There is a Companion Book to accompany each of the texts. If used as designed, these Companion Books should help attain the following objectives:

1. The extension and enrichment of science concepts and interests.
2. The development of scientific attitudes.
3. The further development and understanding of the scientific method of problem solving.
4. The clarifying and fixing of correct science concepts.
5. The promotion of language growth.

In the intermediate grades, these objectives may be achieved in many ways. Some of the methods used in the Companion Books are applying concepts to new situations, solving problems, re-

cording data gathered through experimentation or field trips, making charts and maps, working puzzles, and taking objective tests of various types.

The authors are convinced that as the children acquire more skills, new learning should take place—that the Companion Books should not be just testing programs but an application of principles and concepts to new situations; that the lessons should require the using of skills which are necessary in gathering scientific data and solving problems to attack problems similar to those the children have read about in the text. In addition, the books provide interesting, individual activities for summarizing, testing, and recording group work in science.

FILMSTRIPS

A number of filmstrips have been prepared to correlate with the books of The How and Why Science Series. These extend and enrich certain concepts presented in the books, and enable the teacher to achieve her objectives more easily, quickly, and successfully.

The filmstrips have been prepared in series, with three strips in each series—on primary, intermediate, and upper-grade levels. For example, in the series on Weather, Filmstrip #1 ("We Learn about Weather") is designed for the primary grades; Filmstrip #2 ("Changes in Weather") is designed for the intermediate grades; and Filmstrip #3 ("Understanding Weather Conditions") is designed for upper grades. The strips are available singly or in series. Further information about them will be sent upon request.

AN OUTLINE SHOWING THE DEVELOPMENT OF CONCEPTS

Although each Teacher's Manual contains a detailed outline for a year's work, the plan and organization of the three intermediate books of The How and Why Science Series are shown in chart form on the next two pages.

A large, more detailed chart is published separately. In this separate chart the horizontal development shows in more detail the growth of the concepts, and the vertical columns present more elaborate outlines of the material covered in each book.

Content Areas	*The How and Why Club—Book IV*
LIVING THINGS ANIMALS (*See also detailed chart published separately*)	Animals have structural characteristics and habits which have made it possible for them to survive. Many animals are very important to man.
PLANTS (*See also detailed chart published separately*)	Plants have characteristics and life processes which have made it possible for them to survive. Plants are very important to man.
THE BALANCE OF NATURE (*See also detailed chart published separately*)	Plants and animals depend upon each other.
PHYSICAL ENVIRONMENT WEATHER (*See also detailed chart published separately*)	The weather affects the surface of the earth.
THE SOLAR SYSTEM (*See also detailed chart published separately*)	The sun and moon affect the earth. Some constellations we see in the winter sky.
EARTH STUDY (*See also detailed chart published separately*)	The surface of the earth is continually changing. Fossils.
FORMS OF ENERGY (*See also detailed chart published separately*)	Heat is important to us. Light is important to us. Magnetism helps us. Electricity is important to us.
AVIATION (*See also detailed chart published separately*)	Aviators must follow regulations. A plane is built to fly.
HEALTH STRUCTURE AND CARE OF THE BODY (*See also detailed chart published separately*)	The teeth are important parts of the body. Bones and muscles are important. Our bodies need fresh air.
FOOD AND DIGESTION (*See also detailed chart published separately*)	The body needs food for growth and energy. Foods have to be digested before the body can use them.
BACTERIA AND DISEASE (*See also detailed chart published separately*)	Foods should be kept from spoiling.

How and Why Experiments—Book V	*How and Why Discoveries—Book VI*
Animals have modifications and life processes which have made it possible for them to survive.	Animals are continually struggling for existence. The most important factor in the struggle is food. Animals are able to get food by means of special structures that fit them to the particular food they eat. Animals use food for growth and energy. Species of animals have survived because of these modifications and life processes. Water birds are especially fitted for life in or near the water. Other water animals are adapted for life in or near the water.
Plants have modifications and life processes which have made it possible for them to survive.	Plants grow and reproduce by means of cells. Water plants have characteristics which enable them to live near or in the water.
Man has upset the balance of nature by destroying wild life.	Man is now trying to repair the damage he has done to the balance of nature by conserving wild life. There is an interdependence between the plants and animals in a pond.
The factors involved in weather are air, sun, and water.	The Weather Bureau helps us by forecasting the weather.
The movements of the earth affect our lives.	The earth is a part of the universe. The earth belongs to the solar system. The earth and the moon. Besides planets and stars, there are other heavenly bodies. Astronomers use many instruments in studying the sky.
	The story of the earth. The importance of minerals to man.
Heat is produced in several ways. Air is used by man to do work. Electricity causes lightning. Machines make work easier. Sound is important to us.	Man uses air in many ways. Water is important to man. Magnetism and electricity. Sound is an important form of energy.
Planes use air pressure to fly.	Man travels through the air in several ways.
The skeleton does important work. The muscles do important work. The nerves do important work. The body needs care if it is to work well.	The skin is made up of cells. The body needs care if it is to build up resistance to disease.
Foods keep our bodies warm. Foods have to be digested and circulated so they can produce energy.	Human beings eat for energy. The relation of water to health.
Bacteria are plants that are important to man.	The community health should be safeguarded. Diseases have causes.

HOW AND WHY EXPERIMENTS—BOOK V

SCIENCE PROBLEMS

I. THE INTERDEPENDENCE AMONG LIVING THINGS

PROBLEM A. How do plants help in maintaining a balance of nature?

1. Weeds have survived and become economically important.
2. Seedless plants have survived and become important to man and other animals.

PROBLEM B. How do animals help in maintaining the balance of nature?

1. Some animals migrate.
2. Some animals hibernate.
3. Animals are protected in many other ways, such as by color, defense organs, senses, and changes in form.
4. Animals have an effect upon each other.

PROBLEM C. How are insects important to man?

1. Some insects are harmful.
2. Some insects are helpful.
3. The life histories of insects affect their economic importance.

II. SOUND

PROBLEM A. What makes sound?
PROBLEM B. How does sound travel?
PROBLEM C. How fast does sound travel?
PROBLEM D. How well do you hear?

III. HEAT

PROBLEM A. How does heat affect solids?
PROBLEM B. How does heat affect liquids?
PROBLEM C. How are gases affected by heat and cold?

IV. AIR PRESSURE

PROBLEM A. How do we know that air has pressure?
PROBLEM B. How does air pressure work?
PROBLEM C. What makes an airplane fly?

V. THE WEATHER

PROBLEM A. How does air affect the weather?
PROBLEM B. How do we measure air pressure?
PROBLEM C. How does water affect the weather?
PROBLEM D. What causes thunder and lightning?

VI. HOW HEAT IS PRODUCED

PROBLEM A. Why do fuels produce heat?
PROBLEM B. What happens to carbon when it burns?
PROBLEM C. In what other ways do we obtain heat?
PROBLEM D. How do our bodies keep warm?

VII. THE WORK OF THE BODY

PROBLEM A. How is food digested?
PROBLEM B. How do we keep well?

VIII. FOOD-MAKING IN PLANTS

PROBLEM A. How do plants get and use food?

IX. THE BALANCE OF NATURE

PROBLEM A. How do plants and animals depend on each other?
PROBLEM B. How do plants and animals live together?

X. THE SEASONS

PROBLEM A. What causes day and night?
PROBLEM B. What makes a year?
PROBLEM C. What causes the seasons?

XI. BONES, MUSCLES, AND NERVES

PROBLEM A. How do bones work?
PROBLEM B. How do muscles work?
PROBLEM C. How do nerves work?

XII. CONSERVATION OF NATURAL RESOURCES

PROBLEM A. How can we help with conservation?

XIII. HONEY-MAKERS

PROBLEM A. How do bees live and do their work?

XIV. BIRDS OF PREY

PROBLEM A. How are owls and hawks important to man?

XV. LIFE AMONG THE ANTS

PROBLEM A. How are ants important to man?

XVI. MACHINES

PROBLEM A. How do machines make work easier?

ACTIVITIES USEFUL IN SOLVING THE PROBLEMS IN *HOW AND WHY EXPERIMENTS*

I. THE INTERDEPENDENCE AMONG LIVING THINGS (Pages 5–133)

Problem A. How Do Plants Help in Maintaining a Balance of Nature?

Science Concepts:

1. Some plants are able to survive because they produce a large number of seeds.
2. Weeds are plants that grow where they are not wanted.
3. Some weeds survive because they produce many seeds; some because they store food in thick roots.
4. The scattering of seeds in many ways helps plants to survive.
5. Crop seeds are often contaminated with weed seeds.
6. Some weeds are poisonous.
7. Seed-eating birds help to destroy weeds.
8. Some plants do not grow from seeds.
9. Ferns reproduce by spores. They have roots, stems, and leaves.
10. Ferns are propagated by cuttings.
11. Mosses also reproduce by spores instead of seeds.
12. Some mosses are useful.
13. Fungi are plants that reproduce by spores.
14. Fungi are not green like mosses and ferns. Therefore, fungi cannot make their own food.
15. Mushrooms are fungi that have a stem, cap, and gills. Some are good to eat.
16. Bread mold is a fungus that spoils bread.
17. Yeast is a fungus that we use in making bread.

18. Some fungi, such as corn smut and wheat rust, are harmful.
19. Bacteria are the smallest of all fungi.
20. Some bacteria cause disease; some are useful; some are harmless.
21. Bacteria need food and moisture to grow.

HOW WEEDS GROW AND SURVIVE (Pages 5–14)

This story is intended to interest children in weeds and how to eradicate them. Since many weeds belong to the composite family, weeds are introduced with some common composites.

Composites are plants having their flowers in heads or clusters. In fact, what appears to be one flower really is a whole bouquet. Since each flower produces a seed, composites are prolific. Also, many composites have plumes on their seeds that help to scatter them far and wide.

Suggested Activities:

The children may carry out the activities suggested in the story. If they count the flowers in a dandelion head, they will realize how many seeds one dandelion may produce. Multiplying this number by the number of dandelions in a yard may impress upon them the necessity for digging dandelions.

If some other weed, like ragweed, is surveyed in the same way, the number of seeds found on just one plant will be astonishing. The approximate number of seeds per plant for a few common weeds is estimated to be:

Tumbleweed	—129,000
Purslane	— 80,500
Lamb's quarter	— 72,500
Russian thistle	— 24,700
Pigweed	—117,500
Alfalfa	— 50,000

To impress the efficiency of methods of seed dispersal, a field trip may be taken to find a plant that is losing seeds. Some tree, such as a catalpa, maple, basswood, or pine which has no others near it, is good. Starting with the tree as a center, let the children

walk in straight lines like the spokes of a wheel, picking up all the seeds they find. Tell them to keep walking until no more seeds from that tree are found. As many as fifty children may participate in the activity. When all have stopped, estimate the distance to the farthest child, by pacing. Count the seeds gathered and record the number and the area they covered.

If cockleburrs grow in the region, another interesting modification can be studied. With a hammer, crack the seed covering and find the two seeds inside. Plant both seeds, water, and observe what happens. One seed should grow and the other remain dormant. The second seed remains in the ground to grow the second spring.

Some of the poisonous weeds are:

Aconite	—to sheep and horses
Arrowgrass	—to sheep and cattle
Cockleburr seedlings	—to hogs, chiefly
Death camas	—to sheep, chiefly
Greasewood	—to cattle, sheep
Jimson weed	—generally poisonous in large quantities
Loco weed	—to horses, chiefly
Low larkspur	—to cattle, chiefly
Lupines	—to sheep, chiefly
Milk vetch	—to sheep, chiefly
Whorled milkweed	—to sheep, cattle, horses
Sneezeweed	—to sheep, chiefly

Many state agricultural colleges publish bulletins on the common weeds of the state and are glad to send them to interested teachers.

Some weeds are commercially valuable. Also, some weeds have edible parts. A study of useful weeds would prove interesting to boys and girls who go camping or participate in activities such as those of the Boy Scouts or the Camp Fire Girls. *Wildwood Wisdom* by Jaeger, and the Cornell Rural School Leaflet on weeds, give some of these uses.

The children may examine, through hand lenses, some common weed seeds that often contaminate grass and clover seeds. Then they may look at a handful of the grass seed to see if it has any weed seeds in it.

The weeds common to the region should be gathered in the field, and ways of destroying them discussed. Often on field trips in September, birds will be seen clinging to thistle heads and other weeds with edible seeds. This would be a natural opening for discussing the birds that would be useful in a garden, yard, or on a farm.

If the children are interested in making collections, winter rosettes of weeds are easily pressed and mounted. Be sure to dig the roots of all rosettes collected. Cut rosette from the root and press between layers of newspapers to absorb the moisture.

SOME PLANTS DO NOT GROW FROM SEEDS (Pages 15–29)

Children often have questions about ferns. Because some so-called ferns, the asparagus ferns, have flowers and seeds, there is a common misconception that ferns have flowers. Asparagus ferns are not true ferns but seed-bearing plants belonging to the lily family. To teach this material, teachers need to know something about plant classification.

The plant kingdom is divided into four great groups or phyla. These are:

- I. Thallophyta
  1. Algae
  2. Fungi (bacteria, yeasts, molds, mushrooms)
  3. Lichens
- II. Bryophyta—Mosses and Liverworts
- III. Pteridophyta—Ferns
- IV. Spermatophyta—Seed plants

Those plants belonging to Spermatophyta are the only ones that have flowers. The Bryophytes and Pteridophytes reproduce by spores. Since one generation produces asexual spores and the next one produces sexual spores, ferns and mosses are said to have "alternation of generations." Spores are special cells of a plant that are set aside for reproduction. The simplest form of reproduction is by means of cell division or fission. Bacteria reproduce this way. The lower the form of plant, the simpler its means of reproduction.

As plants become more complex, they have more complex forms of reproduction. Instead of the whole plant's splitting to make two plants, special cells or spores are produced. If each spore is able

to grow into a new plant, it is an asexual spore. Many of the lower plants such as fungi produce these asexual spores.

If two spores must fuse to produce a new individual, they are called sexual spores. The process of fusion is fertilization. Many of the lower plants produce both sexual and asexual spores. The ways that these spores are formed vary among plant classes, but in general each phylum has similar forms of reproduction.

Ferns produce brown spore cases or sporangia on the undersides of their fronds. In these sporangia are minute asexual spores that look like dust to the naked eye. When these spores fall on damp rich woods' soil, they germinate into tiny green plants about the size of the end of one's finger. We rarely see this generation of the fern because the plants do not grow unless under the proper conditions. Florists propagate ferns by rootstocks or runners.

The tiny plant that germinates from an asexual spore of a fern is known as a gametophyte, and on it grow the organs that produce the sexual spores. Sexual spores are called gametes. The male gametes are motile and swim to the female gametes. The fertilized eggs germinate and form the leafy plant which we know as the fern. It is called the sporophyte generation because upon it are produced the asexual spores.

Mosses have a similar life history. The gametophyte of the moss is the leafy part that we know as the moss. The sporophyte generation is the tiny stem growing from the end of a leafy cluster and producing the sporangium containing asexual spores. The teacher may get more information concerning the life histories of plants from a high school biology text or a botany text. Since the major concept to be developed here is that plants have various modifications which help them to survive, we are not interested in teaching children technical details.

Suggested Activities:

Most schools and homes have ferns growing in window boxes or pots. The children may notice the brown dots on the underside of the leaflets and ask what they are. Or questions may arise concerning the growth of ferns, such as "Why does touching the end of a fern make it turn brown?" or "Why don't ferns grow well in a sunny window?"

If a woods is near enough for a trip, children should visit it and see the conditions under which ferns grow naturally.

There are so many varieties of wild fern that the children may discover interesting adaptations, such as the cinnamon fern in which the sporangia are clustered on special stems and look like bunches of cinnamon, or the walking fern whose fronds bend over and take root where they touch the ground.

If a microscope is available, a fern sporangium may be scraped from a leaflet onto a clean slide and examined. It may be crushed in a drop of water and the spores released. The children will be able to see the individual spores under the low-power objective of the microscope. Lacking a microscope, a hand lens may be used to see the clusters of sporangia.

A greenhouse may be visited to see how the florist grows ferns. Or ferns in the room may be repotted. The children will see the underground stem which may be separated between the new shoots and used to start new ferns. They will see that the reason touching the end of a frond injures it, is that it is an unrolling leaf, like a bud, and is very tender.

Moss and ferns may be brought from the woods to plant in terraria. The children should study the environment in which they find the plants and try to duplicate these conditions in the terrarium. For directions for making terraria see another part of this manual.

While at the greenhouse, ask the florist to show you some peat moss—dry moss used for packing bulbs. If a piece is moistened, the children will see how it absorbs water and changes color.

In lake regions this peat moss or sphagnum grows in bogs and marshes. If it is possible for the children to visit such a bog, they will get a better idea of the plant and animal relationships in this type of environment. Peat moss has many economic uses besides its use for packing. The children may be interested in investigating some of these.

Only the commonest fungi are mentioned in this story. Any that are found in the community may be used to illustrate these important plants.

Fungi are plants that lack chlorophyll; hence, they are unable to make their own food. They must get their food from some other

plants or animals. Some fungi grow on living plants or animals. These are parasites. Others grow on decaying organic material and are saprophytes. Some fungi are harmful and some helpful to man. They are important factors in the balance of nature.

If the children begin searching for various types of fungi, they will discover that one of the factors necessary for the growth of green plants is destructive to many of the fungi—that is sunshine. The children will discover that fungi need moisture, food, warmth, and darkness.

The activity given on page 22 is not really an experiment. It is a simple way of demonstrating spores and the way they fall from a mushroom. Different kinds of mushrooms have different colored spores. It is one means of identifying them. Care should be taken that children do not handle poisonous mushrooms. The teacher should read about poisonous mushrooms so as to be able to distinguish them.

There is no one rule by which one can tell poisonous from nonpoisonous varieties. Since mushrooms are raised commercially for food, it may be possible to visit a mushroom cellar in the community to see how they are raised.

Molds are usually considered among the harmful fungi. A few, such as the ones that flavor cheeses, are useful to man, but most of them spoil food. They are so common that the teacher will easily obtain some for study. The new molds that produce drugs such as penicillin and streptomycin have opened up a new field of usefulness for this group of plants.

The children should perform the activity suggested on page 24. For best results the bread should be in a dark, warm place.

After the mold has grown and the children have examined it, let them transfer a bit of the black spores with a needle to a fresh piece of bread. When this grows into a new crop of mold, discuss the way the mold starts and grows. Be sure that the children realize that the mold on the first bread came from spores that were floating on dust particles in the air. Other similar experiments can be made with mold on cheese and fruit.

The children may discuss fungi similar to molds, which attack living things. One of these causes athlete's foot. Many plant parasites are fungi; among these are rusts, smuts, and mildews.

If farming is an important industry in the region, it may be worth while to attack some problems such as "How can we destroy fungus diseases?"

The experiment on page 25 may be carried further and the yeast used to make bread or rolls. The children should understand that the yeast plants are killed by baking and are too small to be seen.

The need for information on bacteria may arise during a unit on health and disease. The extent to which children will go in the solution of their health problems depends upon the age of the children, their previous experiences, and the enthusiasm of the teacher. No subject is more vital to human welfare. Children are usually interested because it concerns themselves.

Thus bacteria may be introduced both as a part of a plant unit and a health unit. In either case, bacteria should be raised and studied. Sterile technique should be as carefully followed as possible. The directions given on pages 27 and 28 will produce colonies, but if the teacher can make some gelatin or agar cultures to supplement the potato cultures, the results will repay her efforts.

Wide-mouthed fruit jars may be used as suggested in the book. Regular petri dishes are better for use with gelatin and agar. Test tubes with cotton stoppers are good also. Both petri dishes and test tubes are inexpensive and may be bought from any scientific supply house. Pyrex baby bottles, preferably the flat ones, may be used and the sterilizing done in a bottle sterilizer. Simple directions for making these cultures will be found in the pamphlet *Biological and Scientific Material in Health Teaching* which is distributed free by the Metropolitan Life Insurance Company.

When the bacteria grow on the cultures, they will form colonies that have various shapes and colors depending on the kind. The colonies are plainly seen, one common kind looking like yellow glistening drops on the surface of the culture.

Single bacteria cannot be seen without a high-power microscope, and the technique required to make a good stained mount is too difficult for fifth-graders. If the teacher wishes to make some slides for them to see, she can follow the directions in a bacteriology manual or a biology book.

Some bacteria are large enough to be seen without staining. Decaying vegetation in pond water often has very large bacteria

in it. Put a drop of the water on a slide and examine under low power. You may see rod-shaped bacteria. They look transparent unless stained and are often being eaten by one-celled animals.

To see one type of bacteria that helps farmers, pull up an alfalfa plant, clover plant, or any legume. On its roots you should see little nodules. Crush one in a spoonful of water and mount a drop on a slide. The milky fluid contains rod-shaped bacteria (bacilli) that are capable of taking nitrogen from the air and making it into a form green plants can use.

A simple experiment which may be done without apparatus, uses two apples, one perfect, one with a rotten spot. With a sterile needle puncture the rotten spot, then puncture the skin of the sound apple with the infected needle. Place the infected apple in a warm, dark place for a few days. Then examine it.

Any experiments with bacteria should be done carefully and all containers sterilized after using. The sterilizing may be done by baking the containers at a high temperature or boiling for an hour. Needles may be sterilized by putting them into a flame. Darning needles may be used by pushing the eye end into a wooden handle.

Children should be taught not to put their hands near their faces or mouths while working with bacteria and to wash thoroughly when they are through. While the bacteria grown will probably be harmless, children learn a technique that is scientific and should carry over into other activities.

Throughout the solution of this problem, every opportunity should be taken to bring out the ways plants depend on other plants, and the factors of their physical environment. Also, the children should realize how these plants are important to human beings and how we help to propagate or destroy them.

Problem B. How Do Animals Help in Maintaining the Balance of Nature?

Science Concepts:

1. Animals have many ways of surviving.
2. Many birds migrate; some stay in one place.
3. Man is interested in learning more about bird habits because birds are important to him.

4. Scientists band birds to learn more about their habits.
5. The government has a department the members of which devote their time to the study of animal life.
6. Ornithologists are people who study birds.
7. Ornithologists have some ideas as to why birds migrate, but they are not sure.
8. Scientists do not say a thing is true until they have sufficient proof.
9. Some birds that do not migrate seasonally are gradually extending their range.
10. Most birds are helpful to man because they destroy harmful insects, weeds, and rodents.
11. Birds migrate along rather definite flyways.
12. Birds fly long distances from their breeding grounds to their winter feeding grounds.
13. Birds must survive storms, lack of food, and other hazards in their migration.
14. Most birds migrate in spring and autumn.
15. Some birds fly without stopping for food; others take a longer time and stop for food along the way.
16. Different kinds of birds have different migration habits.
17. Some other animals migrate.
18. Some animals hibernate.
19. Animals are protected in many other ways, such as by color, defense organs, senses, and changes in form.
20. Man has learned to use other animals.

This problem is an excellent one to use in developing scientific attitudes. Many popular books have given misconceptions concerning the habits of birds. As with other animals below the human being, birds act instinctively. They do not say to themselves, "Winter is coming with cold weather and scarcity of food. I'd better make plans for a trip south." If they did they would probably persuade all their neighbors to do likewise. Yet it is a well-known fact that birds of closely related species vary in their migration habits. For example, among the woodpeckers the redhead migrates, while the downy remains. The golden-shafted flicker migrates and the red-shafted flicker remains. All eat the

same kind of food and have the same habits and protection against cold. Some of our smallest birds, such as the chickadees and titmice remain, while larger, more hardy birds migrate.

Recent studies and experiments with live birds seem to indicate that light may play an important part in determining the time of migration. It has been proved that light affects the reproductive cycle. As the days grow longer in the spring, the reproductive organs are stimulated to activity. This stimulates the mating instinct and the birds start back to the breeding grounds. Some species travel in flocks of their own sex, the males going first and choosing territory before the females arrive. Some species travel in mixed flocks and court along the way. The teacher will find these habits of birds discussed at length in Dr. Allen's books. She should be careful not to assign human characteristics to birds. This material offers a good opportunity to teach the meaning of "theory." A theory is supported by enough facts to make it plausible. The suggested reasons for bird migration given in this chapter are theories.

Bird-banding is practiced by ornithologists for the purpose of keeping records of birds. A permit is necessary and may be obtained by an adult who has sufficient knowledge of birds and a good reason for studying them. His application blank must bear the names of three authorities who vouch for his ability and sincerity. The United States Biological Survey does not encourage promiscuous bird-banding. If a teacher wishes to make such a study, she may get the necessary information and blanks from the United States Biological Survey.

BIRDS MIGRATE (Pages 30–55)

The problem is easily introduced either in autumn or spring. The flocking of birds on the school grounds, the noise of geese flying at night, the finding of dead birds killed during migration are all very natural ways for the problem to arise.

The open season on game birds often brings many questions concerning the laws for hunting birds. The children may bring pheasant feathers to school because they think them pretty.

One group of fifth-graders was much interested in pigeons. Several of the boys had different kinds of pigeons for pets. One day a

racing pigeon stopped at Bob's loft and ate with his pigeons. Bob brought the strange pigeon to school for the others to see. It had a band on its leg. After a discussion of where the bird came from and what should be done with the bird, it was decided to release it. The children were much interested in the way the bird circled and started south in spite of falling snow. Later the children learned that the owner of the bird lived in a city fifty miles south.

The band on the bird's leg raised some questions, and pages 30–34 in How and Why Experiments were read to answer the questions.

A professional pigeon fancier was called in to answer questions on racing pigeons. He brought one of his own birds and released it to show how unerring is the flight of a good racer. He told how the pigeons are trained and raced.

After these experiences with tame birds, the children noticed more wild birds and made comparisons between the two kinds. They set up excellent questions concerning the habits of birds. Any group of children will do the same with a little guidance.

Records may be kept of the birds seen. A big outline map of the western hemisphere on the bulletin board may be used for a migration map. As different kinds of birds are seen flocking, a picture of that bird may be posted near the map. Its range may be found in a bird book or on an Audubon bird card. Its possible route may then be plotted and a line drawn from the place you live to where the bird goes. By using different colored crayon for each bird, the routes may be kept separate.

There is a good opportunity in this study of migration to integrate with the social studies program. Fifth-graders are often interested in maps and finding different places on the globe. If they take imaginary trips with the birds they know, children are interested in finding out something about the regions along the way. The Companion Book for How and Why Experiments contains some activities similar to these.

The economic importance of birds may be learned by making food charts of some of the common birds. The teacher can get government bulletins to help in gathering some of this information.

A debate on "Are starlings more harmful than helpful?" will bring out some startling facts to children who live where starlings

are considered pests. As sources for such discussions, the teacher should get all the authentic information she can from ornithological magazines and bulletins as well as up-to-date books. It is a mistake to think simple story books are good enough for children. The method here is as important as the knowledge gained and this is an excellent opportunity to give practice in the habit of persistent search for truth. *Audubon Magazine* and the *National Geographic Magazine* are excellent sources of information.

While children in most parts of the United States will never see an Arctic tern, they do see other terns. Even children in the prairie states see terns, gulls, and other water birds during migration. If the teacher will go to any lake, pond, river, or even roadside ditches at this time, she may be surprised at the number of water birds that have stopped to feed.

The golden plover is similar to our common killdeer in size and habits. So children may make the comparison.

The speed of birds interests boys. If they compare the size of a bird with an automobile and the speeds of both, they will realize how much fuel a bird needs in order to fly. They might watch birds flying and try to estimate their speed.

Of course the darting flight of a humming bird or hawk after its prey is more rapid and of shorter duration than the average flight. Aymer's book on *Bird Flight* may be read for further information. Feeding shelves will bring birds close to your windows and arouse interest. During migration, many unusual birds often stop for water and food at such a shelf.

SOME OTHER ANIMALS MIGRATE (Pages 56–62)

Many people are surprised to learn that birds are not the only animals to migrate. The story of the salmon is better known than some of the others because of popular stories about salmon. Teachers may refer to David Starr Jordan's famous story or to numerous bulletins distributed by the canneries. Children living near salmon fisheries will, of course, be able to visit them and see salmon. Children everywhere eat salmon and will be interested in their life histories. If there is any kind of fish hatchery in the region, it should be visited.

Monarch butterflies are found in almost every part of the United

States. A little search may reveal masses of them hanging from a tree preparatory to flight. We often come upon flocks of them along the highway where they are caught in large numbers on car radiators. Other examples of butterflies that migrate are given in the May 1937 issue of the *National Geographic Magazine.*

If you live in a region where termites are pests, they should be studied for their characteristics, habits, and means of destruction. The teacher may get information from the United States Department of Agriculture. Many state departments also publish bulletins on termites. If termites are common to the region, the teacher should find some and work with the live insects. A sanitary engineer may be glad to show the children what measures are used to try to eradicate termites.

Mammal migration may be observed in many regions. In the mountains, children notice the fall and spring migration of elk, deer, mountain sheep, and goats. Along the Pacific Coast the appearance and disappearance of seals near the coast is often noticed. But unless their attention is called to it, adults as well as children take these phenomena for granted. The teacher should use these common experiences to help teach this principle of survival. More information may be obtained from U. S. Department of Biological Survey bulletins, from *American Mammals* by Hamilton, and from *Lives of Game Animals* by Seton.

THE STRUGGLE AMONG LIVING THINGS (Pages 63–75)

In earlier books the children have learned about some of the animals that hibernate. Here they learn about hibernation as a function aiding survival.

Different animals that the children know about may be listed and discussed. They may be compared as to ways they spend the winter. Most of the animals that hibernate are cold-blooded, that is, the temperature of their blood varies with changing temperatures around them. Only a few mammals truly hibernate. Some bears, woodchucks, and some bats hibernate. During hibernation the blood flows very slowly, the heart beats slowly, and metabolism almost ceases. The animal appears dead. Cold-blooded animals may be stiff and seem frozen. Breathing may stop and the living cells depend on oxygen absorbed through the skin.

Amphibian and reptilian pets in terraria may go into hibernation or partially hibernate. Turtles sometimes bury themselves in the sand of the aquarium and look dead. A visit to a pond, field, or woods some bright November day may reward you with many hibernating animals. Under stones you may find snakes; under decaying logs, salamanders; and buried in the mud along a shore will be frogs, clams, crayfish, and other animals. After looking at them, replace their coverings.

Digging into a woodchuck hole is quite a task, but the furry ball at the end of the tunnel is exciting to see. Be careful not to injure it.

The legend about ground-hog day is of course not true, but children may believe it. This is a good opportunity to teach another scientific attitude of cause-and-effect relationships. On February 2 discuss the weather and the possibility of a woodchuck's seeing its shadow. If any child thinks the weather will be affected, the teacher may say, "Perhaps it will. The only way to find out is to learn more about weather and woodchucks. How can we do this?" One suggestion may be to keep a record of the weather for six weeks to see if it follows the old saying. One might be to study the habits of woodchucks, and so on.

Conies are rodents, closely related to rabbits. They are interesting because of their habit of making hay. This habit of storing food seems instinctive to many of the rodents. The ones that store food are not true hibernators for they awaken to eat.

Skunks are interesting animals which are known because of their method of defense. Actually they are gentle, shy creatures that give a warning before they shoot. Young skunks make nice pets and never spray their musk unless frightened. But look out if a dog comes near. Children should be taught to respect, not fear, these animals. They should learn about their economic value and their place in the balance of nature.

ANIMALS ARE PROTECTED IN OTHER WAYS (Pages 76–95)

The animals suggested to illustrate protective coloration are selected from different regions to show how, in the struggle for existence, those animals survived that were best fitted to escape their enemies in that environment. The horned lizard, mistakenly called

a toad, is a common reptile of the southwest. Because of its color it is not easily seen on the desert or sandy prairies. Its scaly skin prevents evaporation from its body and also makes it less palatable to possible enemies. Its ability to bury itself in the sand and remain for long periods without food enables it to live through unfavorable weather conditions. Its food is insects, mainly ants, which abound in sandy soil.

All of these modifications have helped the horned lizard to survive. Possibly at one time it lived in other regions but did not survive because the environment was not right. Children should get the scientific principle here that animals have survived because they possessed these characteristics—not that they developed the structures in order to survive.

A horned toad may be obtained from a pet shop, or from a friend from Texas, Oklahoma, New Mexico, or other state where horned toads are found. Any lizard found in your region may be kept for a while in a sandy terrarium and its characteristics studied. Fifth-graders are old enough to begin to move out from their immediate environment, but the starting place should be with the animals of their own region.

Lizards will eat almost any kind of small live insect. Horned toads prefer small ants, but they will eat flies, gnats, and small insect larvae. An easy type of food to keep on hand is a culture of meal worms. These are the larvae of beetles that are found in grain and meal of different kinds. A start may be obtained usually by going to a mill or other place where bran or grain is stored. Farmers often find meal worms. To make the culture, put some bran, meal, or breakfast food into a jar or can. Put in the meal worms. An apple or carrot on top of the bran will supply moisture and food. Then crumple some paper on top of this. Cover with a piece of glass or cardboard and set in a dark place. You will soon have plenty of larvae to feed your animals.

Some horned toads that one fifth grade kept through the winter would bury themselves for several weeks at a time, coming up for food when hungry.

Many butterflies are protected by color. The Viceroy is just one common example found almost everywhere in the United States. Some are protected by their resemblance to the bark of trees.

Some look so much like flowers that they are invisible when alighting. Many butterfly or moth larvae and pupae resemble bits of wood or sticks. If the children search in their own regions they will find many examples of insects that have survived because they have escaped the eyes of birds and other enemies by reason of their shape or color.

Many birds are protectively colored. This is usually true of females and young. Birds and other animals with stripes or spots blend with the shadows and sun-flecked background. Most people who spend any time out-of-doors have been startled at some time by almost stepping upon some animal that was unnoticed until it moved.

More animals change color than most people realize. A first grade kept a weasel in a cage one autumn and watched as the brown hair fell out and was replaced by white hair. These children will always remember that it was a gradual shedding of hair and growth of new hair. No one will be able to tell them that hair turns white in a single night.

Some birds get different colored feathers when they molt in the autumn and spring. Goldfinches and bobolinks do this. In the winter, males are the drab color of the females. In the spring and fall, children may see goldfinches that are mottled looking. Remember that this is part of a seasonal cycle and is not in response to a need on the part of the animal. It is inherited from ancestors that survived because they possessed this characteristic, among others.

Many young birds demonstrate this change in color as they lose their juvenile plumage and grow their adult feathers. Discuss with the children the advantage to a young robin or bluebird of its speckled breast and of the striping of young herons, towhees, or other familiar birds.

In discussing protection afforded by senses, a pet dog and cat will illustrate excellently. Most people who own these pets have observed how much more dogs depend on scent and hearing than upon sight. Many dogs have poor sight. Cats, on the other hand, have good sight. It is a mistaken idea that cats see better at night than in the daytime. Their eyes are so constructed that they see better at night than many other animals do. One reason is that

the pupils of cats' eyes dilate more than those of most other animals. Thus at night more light can enter them. The same is true of owls' eyes. In the daytime the irises of cats' and owls' eyes contract and allow no more light to enter than is needed. So cats and owls also see in the daytime.

The eyes of dragon flies, like other insects, are compound. That means that they are composed of hundreds of small lenses or facets fitted together like honeycomb. Each lens receives the light rays from the side it faces. All these rays together produce the image —what kind of image we can only speculate upon. Dragon flies' eyes are very large and have larger facets above than below. We presume that this modification aids them in seeing the insects upon which they feed.

Even a simple microscope will reveal the structure of a dragon fly's eye. Children can easily catch one of these insects. They are very beautiful and perfectly harmless. They have no way to bite or sting and if handled carefully may be released, after observation, to go on killing insects.

Birds probably depend upon sight more than upon any other sense. By watching a pet bird or common ones on the school ground, children will see how they find tiny seeds and insects. Even chickens show this keen sense of sight.

The horns, quills, teeth, and claws of animals are common trophies possessed by small boys and adults. They may be brought to school and their use to the animal discussed. Notice the barbs on the porcupine's quills which catch in the flesh of enemies that approach within striking distance and pull the quills from the porcupine. This is the time to correct the misconception that porcupines throw their quills. Anyone who has seen a dog's nose full of quills knows how the quills must hurt. But the dog stuck his nose into trouble or the quills wouldn't be there.

The same is true of skunks. A skunk usually stamps its front feet in a sort of pawing-the-ground motion and lowers its head before spraying. That is a warning which a human being heeds. An inexperienced dog may go right on toward the skunk. The skunk then wheels quickly, tail up, and blinds the dog with the liquid. Naturalists have watched skunks and made friends and pets of them, with no dire results.

"Freezing" or "playing possum" are instinctive reactions of many animals to danger. Human beings also sometimes react this way. Many examples of such reaction can be found in any region. Young animals respond to a mother's warning by "freezing." Many birds, rabbits, deer, and others do this. The killdeer is an example of a bird which protects its young by pretending to be injured and leading one away from the fledglings.

The loss of body parts is common among invertebrates. If an enemy grasps the leg of a crayfish, the leg comes off and a new leg grows. Among vertebrates, regeneration of lost parts isn't common. Lizards are an exception. The so-called glass snake is a lizard so cylindrical as to look like a snake. The tail and body are about the same length. The vertebrae of the tail are held together with cartilaginous plates that are easily pulled apart. If the tail is caught it is detached and the body crawls away. It does not go back, however, and gather up the lost part. The author recalls her surprise one time when as a child she and her brother were playing with a lizard. The brother snatched the lizard from her, leaving the tail in her hand. Many children have had similar experiences and may wonder about them. They need not, like this child, have to grow up before satisfying their curiosity.

Bulletin boards, charts, or exhibits could be used to summarize the ways in which animals are protected. One bulletin board that was made in connection with this unit had the caption "What Eats What?" It was a cross section of the ocean showing all kinds of sea animals. The children drew lines from pictures of different animals to their prey. The same idea could be used with a forest scene, a meadow, an orchard, a garden, or a pond. The animals could be cut out free-hand or from magazines. Plant life could be introduced to show the interrelationships there. In schools having an integrated program, the possibilities of getting help from the art department are unlimited.

The ways in which man protects himself should be contrasted to ways he would be protected if he could not reason or anticipate. His dependence upon other animals and plants should be brought out. This problem very naturally integrates with the social studies and teachers can make as much of it as they choose. The science concepts are: that man is an animal who is able to think construc-

tively; that he has made use of the plants and animals of his environment to give him food, shelter, and clothing; that he has survived not because of his greater physical strength and endurance but because of his higher degree of intelligence over the other animals.

This is a good time to introduce the idea of conservation, which will be studied more intensively in a later chapter. Since autumn is usually the hunting season, the subject may be brought up by some local happening. The reasons for bag limits, for a time limit, and for protecting the females and young should be discussed.

CAN YOU PICK THEM OUT? (Pages 92–93)

The answers to the questions are:

1. seal, hawk, deer
2. hawk, cat, tiger
3. deer, rabbit, frog, tiger—actually all are protectively colored when in their own environments.
4. bear, frog
5. tiger, bear, dog, cat
6. dog, deer
7. squirrel, cat
8. dog, rabbit
9. beaver, seal, frog
10. dog, cat, tiger, squirrel, bear, rabbit

SOME MEANS OF PROTECTION (Pages 94–95)

Crayfish—Hard covering, ability to swim backwards, eyes on stalks, loses appendages, colored like sand.

Eel—Slippery, shape makes it able to move quickly through water, some eels give shocks.

Tiger—Spots, hunts at night, claws and teeth, moves quickly and quietly.

Skunk—Color, odor, keen senses, thick fur.

Porcupine—Quills, night feeder.

Turtle—Color, ability to draw into shell, dives into water.

Elephant—Size, color, trunk, tusks.

Horned Toad—Color, horns, swift movements.

Toad—Color, acrid secretion from skin, burrowing habit.

Quail—Color, flight, warm feathers.
Deer—Horns, color, hoofs, senses.
Snake—Color, shape, scales, quick quiet locomotion.

SOME ANIMALS GO THROUGH UNUSUAL CHANGES (Pages 96–101)

The life histories of insects have been mentioned or given in part in the previous books in this series. Here they are summarized and applied to the principle of survival.

If the children have had previous work in science, they are probably familiar with the life history of a moth or butterfly. If not, or if they are still interested, some caterpillars should be reared in the room. Directions for doing this are given in the manual for the primary grades, or in the references at the end of this manual.

If clothes moths are a pest in their homes, ask the children to bring some live ones the next time their mothers find some. Put the moth larvae into a jar with some scraps of woolen cloth or yarn and keep in a dark place. Observe their growth and transformation. To test their efficiency, try various moth preventives on a few of the moth larvae. Larvae of the codling moth are often found in apples. Cabbage worms are found on cabbage, cauliflower, brussels sprouts, and broccoli. So even in a city, insects may be found to illustrate life histories.

This chapter may be used as illustrative of animal characteristics that aid in survival, or to answer questions that may arise when children are interested in the animals mentioned. Metamorphosis is a type of life history in which the animal hatches from the egg in a form differing from the adult. Butterflies, moths, flies, mosquitoes, beetles, wasps, ants, bees, and some other insects hatch into worm-like creatures called larvae. Because they look like worms, people often mistake them for worms. Worms do not have biting mouth parts or distinct body regions. Larvae do. Worms do not have jointed legs. Most larvae do. Worms breathe through their skins. Larvae breathe through small openings, called spiracles, in each segment. Worms hatch from the eggs as worms, and live and die as worms. Larvae feed, grow, molt, and become pupae, and finally change to adult insects with six legs and other insect characteristics.

Another misconception to be cleared up is the one that butterfly

caterpillars are smooth and moth caterpillars are fuzzy. Some moth larvae are smooth, as for example the sphinx moths; some butterflies fuzzy, as the red admiral.

It is important that children know the life histories of common insects so that they may know how to control them. It is in the larval stage that many insects do the most harm. Many moth larvae feed upon garden plants, crops, trees, and shrubs. Some of these are the army worm, cutworm, tomato worm, tent caterpillar, and measuring worm. Teachers may get information concerning these common pests of their region from government and state agricultural bulletins. The next problem takes up the economic aspects of insects.

These technical details are not important as objectives to be taught, but teachers should have correct concepts so that children's questions can be answered truthfully. The teacher's job is to give the children a wide experience with the common animals of the locality and to direct their observations and questions in such a way as to achieve the major objectives given in the first part of this manual.

Problem C. How Are Insects Important to Man?

Science Concepts:

1. Some insects are harmful to man because they eat plants that man uses for food.
2. Some insects do harm by feeding upon shade and fruit trees.
3. Some insects destroy plants from which man gets fibers for cloth.
4. There are two types of harmful insects, those that chew and those that suck.
5. Chewing insects may be killed with poison; sucking insects may be smothered with a contact spray.
6. Some insects harm man by carrying disease.
7. Some insects may be controlled by destroying their eggs or breeding places.
8. Scientists like Walter Reed and Edward Jenner have helped fight disease.

9. Some insects help man by killing other insects.
10. Some insects make products that are used by man.
11. Some insects help man by cross-pollinating flowers.
12. Insects have certain characteristics which put them in a class.
13. Man tries to control insects by sprays and quarantine.

WHY MAN TRIES TO DESTROY SOME INSECTS (Pages 102–115)

This problem follows very naturally the chapter on metamorphosis, or it could be used to introduce the whole problem. If the children have a garden made in the spring and blooming when school opens, it is an ideal setting for a unit on interdependence.

In early September, most flower gardens have some plants that have gone to seed; some that have both flowers and fruit; and some that are in full bloom. Sunny days will find honeybees gathering their last stores of nectar and pollen, bumblebees busily going in their hit-and-miss fashion from flower to flower, and wasps still making late visits. One is almost sure to find some plants infested with plant lice, or aphids. Nasturtiums, cosmos, and calendulas are very susceptible to these pests. If you examine such plants carefully, you may find the familiar ladybird beetles, "ladybugs," or their worm-like black-and-red larvae.

One fifth grade discovered a bed of nasturtiums that was covered with aphids. They watched them a while and saw ants going up and down the stems. They took some ants and some leaves with aphids on them back to their room to study through hand lenses. They watched the ants milk their "cows." They decided to spray the nasturtiums with something that would suffocate the sucking aphids.

The next day the group went back with a spray to kill the aphids. To their surprise most of them were gone. Upon examining the plants closely, they found ladybird beetles, both adults and larvae, feeding upon the aphids.

In the same garden, the children found larvae of the white-lined sphinx sucking nectar from the four-o'clocks. They took some back to the room and cared for them until they went into the ground to pupate. The following spring the moths emerged.

Children may make a collection of harmful insects or the work

of harmful insects. If you have exhibit cases in the room or hall, these collections with clear, interesting labels, will be instructive to other children or visitors. Colored charts are published by the United States Department of Agriculture as well as by state departments. Many companies that manufacture insecticides give out free material. County agents may be consulted to answer some of the children's questions.

Most of the insects mentioned are common in every community, but they are merely suggestive. There are dozens of beetles that harm trees. Rip off a piece of bark of any dead limb and you will likely see tunnels made by borers. The heart of a tree is often eaten out by beetle larvae, and when the tree falls or is cut, you can find them. Evergreen trees are attacked by many varieties of borers. These may eventually kill a tree.

Weevils are beetles which infest many foodstuffs as well as live plants. Some beetles get into houses and lay eggs which hatch into the familiar so-called buffalo or carpet moths. The adult beetles feed on the pollen of flowers. Others bore into furniture.

Corn-borers are moth larvae. There are larvae that bore into the stems and roots of many other plants. If children pull up weeds like goldenrod and split the stems and roots, they may find some of these borers.

One scale insect that is very common is the elm scale. These appear as small gray scales that may entirely cover the twigs and small branches of the tree. The insects may migrate to near-by shrubs, such as lilacs. House plants are often attacked by scale insects. One of these appears to be a bit of mold or white cotton. It is called the woolly scale. If one of these is scraped onto a slide upside down and examined under a simple microscope, the legs and other parts of the insect will be seen.

On page 109 the word *reproduce* is taught. As has been true in all of the books in this series, we have tried to teach new words in their proper context. In the first grade, the children learned the words *male* and *female*. In the second grade, they learned the word *mate* and were taught the concept that animals mate before laying eggs. They learned that some animals lay eggs which hatch into young, but that some young are born alive. They learned that animals and plants produce young like themselves. Now they

have just enlarged upon their knowledge of ways in which living things produce new living things. The concept has been theirs for a long time. They need a word to express the concept.

A discussion may arise here concerning the different lengths of time it takes for various animals to grow up. The *Natural History Magazine* for September, 1939, has a good chart showing the gestation period, the size at birth, size of adult, and average length of life of various animals.

If you live in one of the grasshopper plague regions, you may start your problem with them. Let the children tell their experiences. A question such as "Why do you suppose we had so many grasshoppers this year?" or "How do you think we might help keep them away next year?" would open up a discussion. You may capture a few grasshoppers and put them into a terrarium full of sprouting corn, oats, or wheat. The rapidity with which they will eat the young shoots is astonishing. If there are any females they may lay eggs in the dirt of the terrarium.

One fifth grade wanted to see the eggs, so spent a period in the garden hunting females. The female has a forked tip to the abdomen, ovipositor, while the male has a rounded abdomen. Hunting for the females taught the children much about sex differences among insects and added to their sex education in a wholesome, natural way.

One of the females found evidently had not yet laid her eggs, and the children were delighted the next day to find her laying her eggs right next to the glass of the terrarium. The eggs looked like grains of wheat and were stuck together with a foamy substance which hardened around them. The children dug the eggs up and put them in a jar outside the window until winter came and froze them. The eggs didn't hatch. To prove anything, some of the eggs should have been left in the ground.

Box-elder bugs are a pest in some regions. Some of them may be captured and kept until they mate, lay eggs, and die. Sometimes the nymphal forms are found and may be kept until they transform.

If flies or mosquitoes are a pest in your region, children can do a great deal to eradicate them. One group had an anti-fly campaign. They surveyed the community for breeding places. When they

found an uncovered garbage can or pile of decaying organic material, they reported to the members of the class, who discussed ways and means of dealing with the matter.

They went to other rooms making short talks about the life history of the house fly and the harm it does. These were illustrated with charts they had made.

They wrote short articles which the local paper not only published but illustrated. As a result, the whole community was made fly conscious, and some good was done. The children felt that they had helped to make their community a better place in which to live.

These problems of community health are ones which fifth- and sixth-grade children can attack in a small way, and help to solve. The author feels that they are much more suitable and wholesome from the standpoint of mental hygiene than the economic and political problems that some teachers are trying to make children attack. Problems of insect control are tangible and give children something concrete to work with. Insects are within their experience. They have spontaneous interest and questions about them. Yet they have economic aspects of which fifth-graders are just becoming conscious.

The teacher should be careful not to pursue the subject past their interest because of her own enthusiasm. There is little if any value in the collecting, killing, mounting and identifying of insects done in some classrooms. It is an adult activity, usually motivated by a well-meaning teacher who thinks she is teaching science. Here, as in all science teaching, we need to keep checking our objectives and make sure that children are solving their own problems, not artificial ones set up by teachers. Also we should be careful that their activities help in the solution of those problems and are not mere busy work, and that the whole process results in the greatest possible value to the children who are participating.

HOW MAN FIGHTS DISEASE (Pages 116–121)

The stories of the heroes of medicine have been much neglected in our elementary education. The children know more about football heroes, movie stars, war heroes, and aviators than they do about the men and women who give their lives for the preservation of other lives. This is not surprising when we read the daily papers

and note how much more space is given to wars, sports, and crime, than to scientific discoveries of a helpful nature.

Teachers will find very little reading material to supplement the story of Walter Reed and Edward Jenner. They will have to read some of the references themselves and give it to the children. These are given in the bibliography. The Metropolitan Life Insurance Company pamphlets, "Health Heroes," are about seventh-grade reading level. Advanced fifth-graders may read part of them. The dramatic element in the lives of these men always appeals to children and gives an opportunity for integration with language arts through dramatization.

The story of Jenner may be read at the time when vaccination is being given. Children who otherwise might fear vaccination often lose their fear in interest when they know something about the origin and reason for vaccination. If you have a school nurse, she may be willing to come and answer the children's questions about vaccination for smallpox and diphtheria.

HOW MAN USES SOME INSECTS (Pages 122–128)

In their visits to the garden, the children may already have seen some helpful insects. This chapter may be used to answer their questions about the reasons for bees visiting flowers. Nasturtiums are used to illustrate the parts of a flower and their functions, because they are common and have large enough parts to be easily seen. California poppies are good to use also, but any flowers having distinct parts will show this interrelationship between bees and flowers.

Children should watch the bees working on the flowers. If they stand quietly and make no quick movements, no one is likely to be stung. They may capture a bee with pollen on her legs, in a glass jar, and examine her at close range. A little pollen may be put on a microscope slide and examined under low power. If some ripe pollen is sprinkled in a drop of sugar solution and examined under the microscope in about an hour, it may be seen germinating. When a pollen grain lights on a receptive stigma, it starts to grow. It sends out a tube that digests its way through the style of the pistil to the ovule or egg cell. When the end of the pollen tube reaches an egg cell, one of the sperm nuclei contained in the pollen

grain moves into the ovule and unites with the egg cell. This is *fertilization* and is followed by the development of the ovule to form a seed. Although fifth-graders do not need to know all of this, the teacher should understand the process well enough to explain in case the children ask. The pollen grain does *not* slide down the style. The grain adheres to the sticky stigma (top of pistil) and only the pollen tube traverses the style (stem below the stigma) to the ovary (enlarged portion of pistil that contains the ovules).

In the garden the children may find flowers in different stages of seed formation. Many children do not realize that flowers form fruit and that seeds are inside the fruits. It is interesting to make a collection of the fruits they can find in the garden. In the collection might be tomatoes, gourds, cucumbers, bean pods, peanuts, and poppy pods.

Summarizing this problem, the children might list the things they would not have if there were no bees, or make a chart showing how we depend on insects.

HOW INSECTS LIVE AND GROW (Pages 129–131)

This chapter summarizes the characteristics of insects. Having observed many kinds of insects, the teacher might ask, "How are all of these insects alike?" After listing the ways the children name, she may tell them that scientists call these the characteristics of insects. She might ask them if they would like to see how their list of characteristics agrees with a scientist's list. Then they can read the chapter and compare it with what they already know. The teacher should be sure that she doesn't use this technical material and terms as a memory exercise. It is valuable only in so far as children feel a need to know it.

CAN YOU PICK THEM OUT? (Pages 132–133)

1. Butterfly, bee, corn borer, silkworm, fly, boll weevil, ladybird beetle, Japanese beetle, mosquito.
2. Praying mantis, dragon fly, grasshopper.
3. Praying mantis, dragon fly, ladybird beetle.
4. Fly, mosquito.
5. Bee, silkworm.

6. Japanese beetle, boll weevil.
7. Corn borer, grasshopper, boll weevil, Japanese beetle.
8. Bee, butterfly.
9. Monarch butterfly.
10. Mosquito.

SAMPLE LESSON AS TAUGHT IN A FIFTH GRADE

The children had been studying bees and still had some questions that were unanswered. One child had brought a paper wasp's nest, and during the discussion it was evident that the children confused bees and wasps. This lesson was intended to clear up the confusion.

Introduction and review:

Teacher: "There were some questions we didn't answer yesterday."
Child: "Does the old queen sting the young queen?"
Teacher: "How many kinds of bees are in the hive?"
Child: "Three—drones, workers, and the queen."
Teacher: "What are the duties of each?"
Child: "The drones are to mate with the queen."
Teacher: "Yes. One drone mates with the queen. After the nuptial flight he dies. What do the workers do?"
Child 1: "They gather nectar and pollen."
Child 2: "They feed the queen."
Child 3: "If a worker bee is detained, does the queen bee sting it?"
Child 4: "Is there a queen hornet?"
Teacher: "Those are good questions," (as she puts them on the board). "What do the worker bees do with the nectar?"
Child: "They make honey and wax."
Teacher: "What other duties have the workers?"
Child 1: "They feed the drones."
Child 2: "They fan their wings to make a circulation in the hive."
Child 3: "They feed the larvae."
Child 4: "And make cells of wax."
Teacher: "What does the queen do?"

Child 1: "She lays eggs."
Child 2: "She makes bee bread."
Teacher: "Do you all agree with that?"
Child 3: "The queen can't gather pollen and nectar."
Child 4: "Why?"
Child 3: "Her tongue isn't long enough."
Teacher: "What *does* the queen do?"
Child 5: "She leads the swarm and lays eggs."
Child 6: "Is there a queen in the demonstration hive?"
Child 7: "Yes. The other bees wouldn't work without a queen."
Child 8: "Does the swarm that leaves the hive with the queen die or form a new hive?"
Teacher: "Another good question." (Puts it on the board. Shows wasp's nest.) "What does this resemble that the bees make?"
Child 1: "The hive. Are all hornets' nests the same?" (Teacher writes questions as they are given.)
Child 2: "Are the cells like the bees' cells?"
Child 3: "Is a hornet family like a bee family?"
Child 4: "Do they build their nests anywhere but in trees?"
Child 5: "Do hornets gather nectar and pollen?"
Child 6: "How does a hornet get into its hive?"
Teacher: "Have you any suggestions for ways to find answers to your questions?"
Child 1: "We could separate into groups and read."
Child 2: "We could go on a field trip and look for wasps' nests."
Child 3: "We could open a nest and look at it."
Teacher: "All good ways. I brought several nests today. Shall we start by separating into groups and studying these nests? Some of them may be opened. There are some books and magazines on the reading table for you to use. Tomorrow you may report on what you find out."

After the work period, the children spent five minutes checking to see which questions had been answered.

The characteristics of bees were listed on one side of the board and the characteristics of wasps on the other side. As they did this the children realized that some characteristics were the same.

These were listed in a column. The differences were put in another column. Some of these differences were:

Bees make honey. Wasps don't.
Bees make cells of wax. Wasps make cells of paper or mud. Bees feed their young bee bread and royal jelly. Wasps feed their young paralyzed spiders or insects. Bees and wasps are not shaped alike.

II. SOUND (Pages 134–149)

Science Concepts:

1. Sound is produced by vibrations.
2. We make sounds by causing the vocal cords to vibrate.
3. When objects vibrate, the air near them vibrates.
4. Sound travels in waves.
5. Sound does not travel as fast as light.
6. Sound travels 1,100 feet a second.
7. When sound waves hit something like a wall and bounce back, they make an echo.
8. No two ears hear exactly alike.
9. The ear is made up of outer, middle, and inner ears.
10. The outer ear turns the sound waves into the ear canal. The waves reach the eardrum from the canal. The eardrum vibrates. This makes the tiny bones of the middle ear vibrate. This carries the sound to the inner ear.
11. In the inner ear the sound waves connect with the auditory nerves. These nerves carry the messages of sound to the brain.
12. The Eustachian tube leads from the middle ear to the throat. It allows the pressure of the air to be the same on both sides of the eardrum.
13. You should learn how to care for your ears to prevent deafness.

Problem A. What Makes Sound? (Pages 134–139)

This unit was written to answer such questions as this: "I was watching a ball game and saw the batter hit the ball. I heard the

crack after he hit it. Why was that?" Over and over again, children notice phenomena having to do with sound.

There are many ways in which the unit may be naturally introduced. The day the children have orchestra they may bring their instruments to science class. Each child may demonstrate his instrument and tell what he knows about how it works. The teacher may ask, "How does Tom make the sound with his drum?" or "Can you think of a way we can make a banjo?"

They may list all of the things that make sound, and try to figure out how they are made. Suggest that someone capture a grasshopper, cricket, and cicada in glass jars. Watch the insects to discover how their sounds are made. Some kinds of grasshoppers make sounds by rubbing their hind legs against their wings, or rubbing their wings together. Some crickets do the same, others rub their wings or legs against bristles on their abdomens. Male cicadas have special drum-like organs on their abdomens for producing sound. The children should try the experiments given in the text. If a tuning fork is not available, similar results may be obtained with a silver fork.

After using the rubber band, try different kinds of strings such as violin strings of gut, silver, or steel.

If the teacher can obtain a picture of the larynx and vocal cords, it will help to clarify the concepts on page 139. A colored chart may be obtained free from Pertussi Cough Medicine Company.

Here is a good opportunity to teach children how to use their voices properly. They should understand that they produce sound by causing the vocal cords to vibrate and that the vibration is produced by air flowing between the cords. The air comes from the lungs and should flow evenly with no tension in the throat at all. A singer or a public speaker understands this vocal apparatus. He uses his larynx as it is supposed to be used, as a wind instrument through which air flows.

Problem B. How Does Sound Travel? (Pages 140–141)

The diagrams on page 140 are more or less theoretical. Sound waves can't be seen, but scientists think they travel in waves radiating from the source. They radiate, not in one plane, as do

the waves on the surface of a pool, but in all directions. The first diagram is an attempt to show this.. The length of a wave is the distance between crests. The more rapid the vibration, the shorter the wave and the higher the pitch of the sound produced. This is illustrated by a circular saw. As it begins to revolve the sound is low. The faster it goes, the higher the pitch, until we may no longer hear it. If the experiment on page 136 is repeated, allowing more and more of the needle to extend from the table edge, this will be demonstrated.

The experiments on page 141 are to demonstrate this spreading of sound waves as they travel. Children's ears will vary in their keenness. Some will need to be nearer the watch than others, to hear it tick.

Using the tube with which to listen, will help the children answer questions about ear phones and other devices people use to focus sound.

Problem C. How Fast Does Sound Travel? (Pages 142–144)

The exact distance sound travels in a second is not so important for children to know, but the comparative speed of sound and light is needed to answer many of their questions. However, the figures given in the chapter may be used as integrated arithmetic. Out-of-doors let someone with a bell ring it at different distances from the observers. Note times at which the children see the bell rung and hear it. Light travels 186,000 miles a second, which is nearly 900,000 times faster than sound. Of course one has to be some distance from the source of sound to notice the difference in speed.

In answering the question of echoes, it would also be interesting to estimate the speed of an echo. Let a child stand at a measured distance from a wall and shout. Time the echo.

If the school has an auditorium or gymnasium, it should be visited and tested for echoes. The children should notice whether or not the ceiling has been sound-proofed. There is a big difference in the acoustics of well-built auditoriums and empty rooms. The class should discuss the fact that materials like curtains, Cellotex, and other such wall coverings absorb the sound waves rather than echo them.

Problem D. How Well Do You Hear? (Pages 145–149)

This problem is one to which we give little thought unless something impairs our hearing enough to make it noticeable. It is not intended to disturb children but rather to inform them as to the way they hear, and how to care for their ears so that they may hear well. It may be difficult to perform the experiments suggested on page 145, if the school is situated on a noisy city street. The problem of sound-proofing a room might be profitably discussed in such a place. The children may suggest where the experiments could be done. Sometimes a basement room is available. The children might discuss why a room below ground level is often more quiet than an upstairs room.

The children may look at each other's ears and compare them with the ears of dogs and other animals they have studied. Questions like "Why does a dog seem to hear better than you do?" or "What can a dog, cat, or rabbit do with his ears that you can't?" will lead to a discussion of the way the outer ear catches sound waves and directs them inward. Fifth-graders probably haven't thought of *how* they hear. A comment such as "I read somewhere that there would be no sound if there were no ears to hear it. Do you believe that?" will challenge their thinking and start a discussion on the function of sound in their lives. The class can't settle it. We don't want them to. An unsettled question is a stimulus to further thought and investigation.

A comment such as "Let's imagine what kind of world it would be without sound," should teach appreciation of good hearing.

If the teacher can borrow a model or chart of the human ear to show the class, she will find fifth-graders extremely interested. The structure of the ear is one of the most intricate and beautiful examples of precision. A great scientist spoke of the skull of a bird as a "poem in bone." It is just as true of the human skull. When one sees the exactness with which the tiny bones of the middle ear articulate with the coiled inner ear, one wonders that more accidents don't occur to render hearing less perfect. A question children often ask is "Why do we get dizzy when we whirl?" The model of an ear will help explain this. The inner ear contains the organ of equilibrium. Certain nerve endings are stimulated by

movement of the liquid, due to the motion of the head. When one whirls, the liquid doesn't move at the same rate of speed. It is something like what happens when you whirl a pail of water. By the time you stop, the liquid is in motion and continues for a short time. This gives the sensation of whirling after the body has stopped. Dancers have a technique for preventing this dizziness as they whirl. They keep their heads from whirling by turning them quickly from side to side.

Every person has had the experience described on page 148. The children may try several demonstrations to further illustrate this change in pressure. Pressing a conch shell to the ear, they can hear a roaring. Putting one's head in a barrel or cupping the hands over the ears makes a slight change in pressure. It also shuts out sounds from outside to a certain extent.

With all this discussion of sound, the common experiences of the children should be discussed and used for illustration, such as how bad colds affect hearing, the way things sound in a tunnel, the way ears "pop" when riding up or down a mountain or elevator, how yawning will help to equalize the pressure and relieve the discomfort. Anything that can be done to help children adjust normally to these familiar puzzling phenomena makes it worth while.

If you have a doctor and a school nurse, call upon them to settle the questions on page 149, *after* the class has discussed them and formed tentative conclusions.

III. HEAT (Pages 150–162)

Science Concepts:

1. Thermometers are used to tell temperature.
2. Temperature is measured by degrees.
3. There are different kinds of thermometers for different purposes.
4. Temperature changes affect substances.
5. Substances expand when heated and contract when cooled.
6. Water contracts when cooled until it is 39.2° F. Then it suddenly expands.
7. Substances exist as gases, liquids, and solids.

This chapter summarizes a number of concepts presented in the

first books of the series, and relates them to some physical principles. It may be introduced in a number of ways. The experience given in the introduction is one that commonly happens. The buckling of sidewalks and pavements that haven't had provision made for expansion in hot weather, is a good starter if school begins in a hot September.

In winter the extremes of cold nights and sunny days may cause discussions of temperature. One group of fifth-graders noticed the big difference in the thermometer readings in two places on the building. A discussion of reasons for this raised a question, "Are all thermometers alike?" They told of the different kinds of thermometers with which they were familiar. Some children brought thermometers, old and otherwise, from home. The teacher provided Fahrenheit and Centigrade thermometers for them to see. No attempt was made to teach the children the difference. She merely told them that the Centigrade thermometer is used by scientists and has 0° for freezing and 100° for boiling. Fahrenheit thermometers are the common ones used, and have 32° for freezing and 212° for boiling. The children verified this by putting both thermometers in packed snow to get the freezing point. They slowly heated water with the two thermometers in it until it boiled, and found that the boiling point differed, but that they were lower than the temperatures given above. The teacher explained that the higher the altitude, the lower the boiling point of water. Since this school was a mile above sea level, it made quite a difference. The children were helped to make the application of why it takes longer to cook potatoes in the mountains than at lower altitudes. With this particular group, this was not too technical, because of their background. Cooking at high altitudes was a practical problem. Otherwise, there would be no reason to introduce it.

The experiences given on pages 154–155 would be good ways to introduce the unit. If the teacher uses them for this purpose, she should have the materials and merely ask, "How can I get the stopper out of this bottle?"

Problem A. How Does Heat Affect Solids? (Pages 155–158)

The children should set up their own problems. Some of their questions might be:

"Why does pouring boiling water onto a cold glass break it?"

"Why does my mother close the windows when she starts putting canned fruit into the cans?"

"Why do the nails on our cabin porch have to be pounded in each spring?"

"Why is the clothesline tighter in winter than in summer?"

The questions will of course depend upon the way the unit is introduced and the children's experiences.

The experiments suggested will work more quickly if the end of the pipe is thrust into a fire. Since this presents a safety hazard, the slower method is more desirable for children to do themselves. If you don't have a piece of pipe, any round piece of metal may be used. An old-fashioned curling iron is good. Be sure the wire is wound smoothly and just loose enough to slip a knife under it. Be careful not to heat the wire, or it also will expand. Let the children suggest ways to get the wire off.

Dry cells may be bought at the ten-cent store. Copper wire offers less resistance to the flow of electricity than most metals, but is heated a little. Insulated wire need not be used in the experiment.

The experiment on page 158 is so simple that the children should all be allowed to do it. They may suggest variations, such as putting the tumblers in snow, or trying the same experiment with bottles and glass stoppers. This is practical and may be applied to many common problems of how to open jars and bottles.

A coffee can in which coffee has been vacuum-packed may be used to illustrate expansion of solids. Put the lid on it. Stand on the stove a minute. See how tight the lid becomes as the can expands. To get it off, either heat the lid or cool the can. Cooling causes solids to contract.

Problem B. How Does Heat Affect Liquids? (Pages 158–160)

Any kind of bottle may be used for the experiment on pages 158–159. A pop bottle or milk bottle would do as well as the one mentioned as long as you have a cork to fit. The cork must have a glass tube through it. The experiment may be continued further

by packing ice and salt around the bottle and freezing the water.

Children have known since they were in the first grade that water expands when it freezes. This chapter attempts in a simple way to explain the apparent paradox of water's behaving differently from other liquids when cold. When they realize that water reacts as any other liquid to temperature changes except between the limits of 39.2° F. to 32° F. it will help explain many weather phenomena they observe.

The experiments should be repeated with different liquids. Rubbing alcohol may be used to show that it expands when heated and contracts when cooled. Be sure not to have a flame near the alcohol for it burns easily, nor to drop any on a varnished table. It will remove varnish. Since the freezing point of alcohol is much lower than that of water, you won't be able to freeze it. This will help children answer the question of why alcohol is used in automobile radiators in winter.

Remember that it is the water in milk, fruit juices, and many other liquids that makes them expand when they freeze.

Problem C. How Are Gases Affected by Heat and Cold? (Pages 161–162)

Since air is the commonest example of a mixture of gases, just as water is the commonest liquid, many experiments may be performed with air to illustrate this principle. The one suggested on page 161 is very simple. A similar one is to cool a milk bottle. Then stretch a rubber balloon over the mouth and stand the bottle in hot water. The expanding air will blow the balloon up. Cooling the bottle again will allow the balloon to go down.

Most gases are dangerous to use in a classroom or are not easily obtained. After the children have studied the unit on carbon, they may prepare CO_2 and try heating and cooling it.

IV. AIR PRESSURE (Pages 163–177)

This topic follows III very naturally, but doesn't necessarily depend on it. It may be introduced to help answer questions on airplanes or some other machine using air.

We use air and it is necessary to life. This chapter enlarges upon concepts presented in the first books of the series. If the children haven't had these simpler concepts, the teacher should begin with them and build to the ones given here.

Science Concepts:

1. Air is all around us everywhere.
2. Air contains oxygen we use in breathing.
3. Air expands when heated and contracts when cooled.
4. Air presses in all directions.
5. Air pressure helps us in many ways.
6. Air has pressure because it has weight.
7. Air has a pressure of 15 pounds per square inch at sea level.
8. We use compressed air to do work.

PROBLEM A. HOW DO WE KNOW THAT AIR HAS PRESSURE? (Pages 163–166)

Children enjoy these simple experiments with air. They are harmless and require no complicated apparatus. Children will think up other illustrations of air pressure if the teacher suggests, "Anyone who has an experiment tomorrow may do it." The child who has an experiment must know what it proves and assemble the materials with which to perform it. The others may try to figure out what he is attempting to demonstrate. It is important in all science work that children be allowed to contribute their ideas. If they are led to have scientific attitudes toward their work, they will challenge any activities that do not further the solving of their problems or open up new interests. Often children suggest ideas that seem very simple or obvious to an adult, but if these ideas contribute to the discussion and are sincere, they should be used. However, there is a fine distinction between play and interesting worth-while activities. It requires good judgment on the part of the teacher to recognize this distinction. Failure to encourage child initiative, or ridicule by fellow students, will often do more harm than a little time spent in activities which may seem valueless to the teacher. Yet too much wasted time may lead to poor

work habits. A good teacher will direct the solution of problems in such a way that there is a balance between the two.

The experiment on page 163 works only when the neck of the bottle is quite small. It may be tried with different sized bottle necks, and the reasons for its failure with large necks discussed. If the bottle is emptied by tipping it slightly and then held vertically, the children can see how a bubble of air goes in as a drop of water comes out.

Being liquid, water has a tendency to flow toward a lower place because of gravity. Water is heavier than air just as the bottle is. If the boy didn't hold the bottle it would be pulled to the earth. If a milk bottle is filled and inverted, the water will run out. The boy can't hold the water as he holds the solid bottle, for liquids flow. If a piece of cheesecloth were held over the mouth of the bottle, the water wouldn't run out. That is because the tiny openings of the cheesecloth furnish enough surface tension to give the air a chance to support the water. Teachers know that air pressure will support a column of water 34 feet high at sea level. The children learn it on page 185. This experiment starts them to thinking of a reason why the water doesn't run out. The small opening in a small-necked bottle also makes enough surface tension to allow the air to support the water. As one fifth-grader expressed it, "The water stretches between the sides of the glass, kind of like a skin." His own expression of the attraction of water for water and of glass for water was quite unique.

A vacuum-packed coffee can works well for the experiment on page 164. A hole should be made in the lid with a small nail. Be sure that the can is filled to the top and the lid on tight. The purpose of this is of course to explain why two holes are necessary in a can before it will pour. The idea to be developed here is not only that air has pressure, but that air has to go in one hole and push the liquid out the other.

There are many simple demonstrations showing that air has pressure. The rubber suction cups used to fasten things to windshields work by air pressure. A rubber sink stopper can be used to lift a piece of glass or any smooth object. Wet it and slide it over the smooth surface, pushing out the air between the rubber and the object. It is interesting to find out how heavy an object can be lifted.

The air presses on the object and the disk, holding them together. A plunger used to clean drains works on the same principle and may be used in a class demonstration. A new one can be obtained at the ten-cent store. As you push the plunger down, you push out the air from the rubber cup. Air pressure from below pushes on the clogged drain as the plunger is raised. The pushing up and down dislodges the dirt.

WHAT MAKES AIR PRESSURE? (Pages 165–166)

The experiment on page 165 is very simple but must be done carefully to get accurate results. Be sure that the balloons or sacks are put back on the stick at exactly the same places as they were originally.

The safety rules given on page 167 should be practiced every time an experiment involving fire is done. The teacher should first go through a demonstration, letting the children read or tell what should be done. For example, she may hold a candle in her hand and ask "If we are going to use a lighted candle, what must we do to be safe?" The children should suggest a holder, a metal tray under it, and so on. Though this may seem detailed, it is very important.

The experiment on page 168 has another factor not mentioned in the text which some child may question, that is, the removal of oxygen from the air by the burning paper. If the egg is put in the bottle neck immediately upon dropping the burning paper into the bottle, there is very little time for air to escape. In presenting this experiment, the teacher will find it more challenging if the children read the directions, close their books, and then tell her what to do. The teacher may then lead a discussion on why the egg went into the bottle. This should bring out the fact that something caused unequal pressure. There was more pressure on the outside than on the inside. This might be due to expansion of warm air or removal of some of the air by the burning, or both. Unless the children already have the concept of oxygen, do not introduce it at this time. Before burning the paper, the children should try putting the egg through the bottle neck to prove that it won't slip in by itself.

Problem B. How Does Air Pressure Work? (Pages 169–174)

Some simple activities leading up to suction will help clear up misconceptions. The word *suction* is misleading in itself, for it is not a pulling but a pushing process. In the third grade, children learn that by removing the air from a tube they can cause a liquid to flow into their mouths. They learn that it is the air pressure on the outside surface of the liquid which pushes it up into the tube, when pressure is lessened on the surface of the liquid in the tube. This simple demonstration should be reviewed here. Take a piece of glass tubing open at both ends. Put it into a dish of water and by closing the top of the tube with a finger, lift some water in the tube. The air pressure on the outside of the tube is so much greater than that of the small amount of air in the tube, that water stays in the tube. When the finger is removed from the top of the tube, the air pressure is equalized and gravity pulls the water down.

The children should examine and experiment with medicine droppers, fountain pens, and other devices using this principle. If you can obtain an old vacuum cleaner, take it apart and see how it works. The way the dirt is forced up into the cleaner may be illustrated by picking up dirt with a medicine dropper.

The experiment on pages 170–171 is a spectacular one. If you haven't a gas burner, an alcohol lamp or canned heat may be used. The glass tubing must be revolved slowly as it heats, to prevent uneven heating and cracking. The tubing must be held far enough from the flame to prevent burned fingers. It gets quite hot. Also, care should be taken not to touch the ends of the tubing that have been in the flame, and not to lay it on inflammable material. The glass remains hot after the red glow has disappeared.

It takes a good big breath to blow enough air into the water to make a fountain. Children enjoy seeing who can make the biggest one. If only one tube is made, the end can be sterilized after each child tries it, by dipping it first in alcohol, then in clean water.

If any building is going on in the neighborhood where compressed air is being used, it should be visited. There are so many places where compressed air is used in a practical way, that a little investigation usually reveals one.

The experiment on page 174 is to help explain the way water is

forced out of an under-water tunnel. The funnel may have to be held down or the air may push it up. Of course as soon as the boy removes the end of the funnel from his mouth, it will fill with water again. If you do not have a glass funnel, a tumbler may be filled with water and inverted over the cork in the water, then a straw inserted under the edge of the tumbler and the water blown out.

Problem C. What Makes an Airplane Fly? (Pages 175–177)

The text and diagrams simply apply to flight the principles of air pressure. Most boys will know the terms that are given. The term *lift,* like the word suction, is misleading, but it is used by aviators. Lift is produced in a similar way to suction. It may be demonstrated by several simple experiments.

One may hold a strip of paper with the end against the lower lip. Blow hard over the upper surface of the paper. The pressure on top is lowered and the greater pressure below pushes the paper up. Anyone who has ridden in a plane has felt this pressure beneath the plane as it takes off.

Another simple demonstration of this principle uses a spool and a small piece of paper. Hold the spool against the lips and the paper against the other opening of the spool. Blow through the spool against the paper. The paper will be pushed against the spool.

V. FACTORS THAT AFFECT THE WEATHER (Pages 178–195)

Weather is a topic which usually introduces itself. A sudden storm, unusual clouds, decided changes in temperature, a trip spoiled by rain, a radio announcement of some disaster caused by storms all stimulate questions. During the recent war we heard much about weather conditions. One group of children started discussing weather during the invasion of Finland. Another group became interested when a boy brought a piece of a ship that had been grounded by a storm. Increase in air travel has made people more weather conscious.

Because air plays such an important part in weather, the study of air should precede the problems on weather. However, if a

discussion of weather should start naturally, the children may set up their problems and read in either chapter material needed to answer their questions.

Science Concepts:

1. Weather is changing constantly everywhere.
2. In different parts of the country the weather may be different.
3. Weather is very important to us.
4. The sun, air, and water make weather.
5. Unequal heating of air makes a difference in its pressure.
6. This difference in pressure starts currents that are called convection currents.
7. Winds are started by big convection currents.
8. Winds blow from places of high pressure to places of low pressure.
9. Air pressure is measured by a barometer.
10. Low air pressure causes a low barometer and high air pressure causes a high barometer.
11. The higher one lives above sea level the lower the barometer will be when normal.
12. A falling barometer usually means a storm, while a rising barometer indicates fair weather.
13. Air contains water in the form of water vapor.
14. Water vapor is a gas and is *invisible.*
15. Warm air will hold more water vapor than cold air.
16. When warm, moist air is cooled, the moisture is condensed and forms drops.
17. If the drops are tiny enough to remain suspended in the air, they form clouds or fog.
18. If the drops are too heavy to remain suspended, they fall as rain.
19. Snow is formed when water vapor is suddenly chilled to below freezing.
20. Sleet is formed when rain is frozen on its way down to the earth's surface.
21. Hail is formed by rain freezing and being tossed up and down until it accumulates layers of ice and snow.

22. Lightning is a big spark of static electricity.
23. Thunder is the noise made by the sudden expansion of air when lightning heats it.
24. Dew is caused by water vapor from the air condensing on cool objects such as grass and the earth.
25. Frost is caused by water vapor freezing on objects.

PROBLEM A. HOW DOES AIR AFFECT THE WEATHER? (Pages 179–184)

Suggested Activities:

A trip out-of-doors on a sunny day is a good activity with which to start solving this problem. Suggest that the children feel different objects that are in the sunshine, such as soil, sidewalk, tree trunk, glass, wood, or metal. Have them feel the air above these objects. If a pool or other body of water is near enough to visit, have the children test the temperatures of water and land, by feeling. Repeat in the shade. If individuals do not agree, the necessity for using scientific methods for obtaining accurate results will be demonstrated by having the children use their thermometers to get the temperatures of various substances such as water, sand, snow, grass, or garden soil. These examples will depend on the time of the year the unit is taught. Take the temperatures in the shade and sun, and compare them with temperatures of the air in the same places. This will develop the concept which is necessary to the understanding of winds—that different substances absorb and radiate heat at different rates. The children need to understand also that sunlight heats the air very little as it passes through it—that the air is heated by the earth with which it comes in contact.

A discussion of why weather is important will stimulate a desire to know more about the causes of weather.

The main cause of weather is the change in the temperature of the air. Anyone who has gone to a lake, seashore, mountains, or other place where there is inequality in the heating of the earth's surface, has experienced the changing breezes at evening and morning. Even driving near a river will demonstrate the currents

of air set up when we have adjacent layers of cool and warm air.

Convection currents are felt as drafts in a room, or around a fireplace or a bonfire. They may be demonstrated in many ways. Children may hold streamers of tissue paper below and above a window that is opened an inch. They can both see and feel the "draft."

A simple way to show convection is to set a lamp chimney over a candle supported upon two blocks of wood. The wood provides a place for the cold air to enter. Light the candle, place the chimney over it, and hold a piece of smoking punk or incense near the base. The smoke will show the air currents as the cool, heavy air pushes under the chimney to equalize the pressure.

Since air expands as it heats, expansion would occur in all directions if nothing stopped it. The air can't go through the glass, and colder, heavier air is pushing in at the bottom, so the only place for the warm air to go is up. Many people have the misconception that "warm air rises." This, of course, is not true since gravity pulls everything toward the center of the earth. Anything leaving the earth's surface must be pushed up. In the experiment on pages 180–181 this principle is demonstrated. If any of the children have the idea that warm air rises, the teacher can use it to develop critical reading by saying something like this, "What holds air to the earth? Would it be likely that air would move away from the pull of gravity?" Of course everything that floats in either air or water is pushed up in some way.

Children should observe the wind for several days. Notice its direction and speed. Watch for the effect of air currents on smoke from chimneys. Observe the conditions of sky and air temperature when the wind changes direction or velocity. Collect pictures and clippings telling about winds of storm velocity. These make an interesting bulletin board.

A simple wind sock may be made of unbleached muslin. Fasten a cone-shaped bag to a hoop made of light-weight wire. Fasten the hoop by four strings to the end of a long pole. The pole may be erected in the school yard by planting it in a can of cement or tying it securely to some other support. By it, the direction of the wind may be observed. A simple way to tell wind direction is to hold up a wet finger. The coldest side is on the wind side.

Problem B. How Do We Measure Air Pressure? (Pages 184–187)

Having learned that air has pressure, the little experiment given on page 184 may suggest itself. A simple barometer may be made by partly filling a pop or vinegar bottle with water and inverting it in a quart fruit jar which is about two-thirds full of water. Mark the level to which the water comes in the pop bottle. There will be some air in the bottle and it will have the same pressure as the air outside has on the day it is made. As the outside pressure changes, it will cause the water in the bottle to move up or down. Of course this isn't an accurate way to measure air pressure, but it will indicate higher or lower pressure. If children haven't performed the simple experiments given in the third grade book of this series, they may be done at this time.

In making a mercurial barometer, you will have to have a regular barometer tube, since ordinary glass tubing doesn't have heavy enough walls to stand the weight of the mercury. Both mercury and tube may be bought from a scientific supply company. If the tube is tied to a yardstick before being filled, it is more easily handled. To fill the tube, tilt it at an angle, and put the mercury into the tube with a medicine dropper. Tap the tube gently to make any air bubbles escape. When full, put a finger firmly over the open end of the tube and invert in the dish of mercury. The mercury will run out into the dish until the level at your altitude is reached. Barometric pressure decreases about one inch for each thousand feet above sea level. That would be 29 inches at 1000 feet altitude, 28 inches for 2000 feet, and so on. As altitude increases, the pressure decreases a little more rapidly. A local weather bureau can give you the exact reading.

Problem C. How Does Water Affect the Weather? (Pages 187–192)

The second factor in causing weather is water. Without water there would be no precipitation. If there were no changes in the temperature, however, neither air nor moisture would be affected. The three factors of sun, water, and air all work together.

If children haven't done the experiments demonstrating water in the air—evaporation and condensation—they should do so here. These may be found in the primary books of the series.

Put some snow or ice into an aluminum pan or tin cup. In a few minutes, fine drops of moisture should appear on the shiny surface. The more water vapor there is in the air, the more quickly moisture will appear. In very dry climates the air may not contain enough moisture to make this experiment work. In that case, the children should discuss reasons why moisture doesn't form. To supply moisture in the air, a pan of water may be heated and the cup held above it. Be sure that there is no visible cloud between the pan and the cup. This should lead to a discussion of ways of supplying enough moisture for health, in the air of a room. Putting salt on the ice or snow will lower the temperature until frost will form on the pan. Remember that water vapor is invisible. It has condensed to form tiny water drops when we begin to see it.

One fifth grade made a chart of all the ways water gets into the air and out of it. The chart looked like this:

Places Water Comes From	*Cause of Evaporation*	*Appearance*	*Cause of Condensation*	*Forms in Which Water Condenses*
Puddles	Heat	Invisible	Cooling	Clouds
Rivers				Rain
Lakes				Mist
Seas				Fog
Boiling food and clothes				Sleet
				Hail
Plants				Frost
Animals				Dew
Ground				Snow

When the children are demonstrating the formation of frost, they should have a thermometer in the salt and ice to see how cold it gets before frost forms on the pan.

Take advantage of heavy frosts to examine frost crystals through hand lenses. Also, allow the boys and girls to look at snowflakes

and try to figure out how snowflakes are made. Snowflakes are formed when water vapor in the air is chilled to below freezing. The molecules of water collect around dust particles to form tiny needle-like crystals. Each crystal is a perfect six-sided prism. The crystals first formed provide a base for others to build the intricate patterns we see in snowflakes. It is said that though all snowflakes have the same six-pointed symmetry, no two have exactly the same pattern. The colder the air at which crystallization takes place, the smaller the snowflakes. In warmer air they have more time to accumulate more water molecules. This may be demonstrated by making crystals of boric acid. Stir as much boric acid as will dissolve in a pint jar of hot water. Let it cool without moving it. Into another pint jar of hot water, stir as much boric acid as will dissolve. Pack snow around the jar. Note the difference in the crystals.

Hailstones show the layers very plainly if cut in two.

Problem D. What Makes Thunder and Lightning? (Pages 192–194)

Most children have experienced a shock after rubbing their feet on a rug and touching something, or heard their hair crack when it was combed. They may have seen sparks in the dark due to static electricity. In an early book they learned that lightning is a bigger spark of electricity. Now they are ready to learn what causes this spark.

No one really *knows* what electricity is, but most scientists believe that it is a stream of electrons. There are two forms of electricity, static and current. Static electricity is caused by friction.

If we think of matter as being made up of atoms, and atoms being like little solar systems made up of positive and negative charges, it may help to explain static electricity. Positive charges are known as protons and are thought to be the centers or nuclei of these miniature systems. Around the protons revolve the negative charges or electrons. Each chemical element has a specific number of electrons and protons within each atom. When those atoms are put together into molecules, which in turn make up the

masses of matter we know as water, copper, glass, and so on, the electrons and protons are balanced.

We think that there are always a number of free electrons in the air, ground, water, and other masses of matter. When the matter is neutral, it has an equal number of electrons and protons. If we rub two of these pieces of matter together, such as glass with silk, some of the free electrons are rubbed off from one and onto the other. In the case of glass and silk, some of the electrons leave the silk for the glass. This gives the glass a negative charge because it has too many electrons to be balanced. The silk has a positive charge because it has lost some electrons. It will soon capture more electrons from the air and the glass will lose its extra ones to the air. So the experiment will have to be done quickly. When the glass rod is rubbed and quickly touched to a finger, it loses its extra electrons to the finger.

If the rod is held near some bits of paper, it will attract them because they are lighter than the rod, and as the electrons jump to the paper, the paper will be drawn up.

Of course no attempt should be made in this grade to distinguish between the positively charged and negatively charged materials. Nor do children need to know about electrons and protons. If, through some experiments, they can get the idea that electricity can be produced by friction and that it can make a spark or give a shock, it will help them understand many common experiences.

Another simple demonstration may be done with a piece of window glass and some bits of cork or tissue paper. Sprinkle the cork or paper on the table. Lay the glass above them supported on two books. The glass should be about an inch above the table. Rub the glass briskly with a piece of wool or fur. The bits of cork or paper will jump around, up to the glass, and to each other. When the bits touch the glass, they become charged like the glass and are repelled. These experiments work best on a cold, dry day. In fact, when there is a great deal of moisture in the air, the static electricity is conducted away from the glass so rapidly that the experiment may not work at all.

If the children become interested in electricity, the teacher will find many simple ways to demonstrate static electricity. Its introduction into this chapter is to explain lightning. Thunder is caused

by the sudden expansion of air. It is something like the noise made by the popping of a paper bag or the firing of a gun. The reverberations are echoes.

The questions on page 195 may be used as problems to stimulate discussion, or as summarizing questions. The first one can be illustrated by diagrams. The arrows will show air moving toward the fire and up the chimney. The second one may not apply if you teach in an air-conditioned building. The children should try to reason out the way the convection currents flow in their own room. A stick of burning incense will help them find out. Since convection currents may occur in water as well as in air, a hot-water heating system works by convection. Hot-air furnaces, a hot-water tank, and many other common appliances use the principle of convection.

A simple activity to show convection in water may be done with two milk bottles, water, and ink. Fill one bottle with warm water and one with cold. Put a few drops of ink into the warm water. Be sure that both bottles are filled to the top. Place a card over the mouth of the bottle containing cold water and invert it on the top of the other bottle. Carefully remove the card so that the water of both bottles comes in contact. The cold water will flow down into the warm water, pushing the warm water up. Since it is colored, the currents are easily seen.

The third question may be answered by "barometer," "changing direction of wind," or "changing clouds." All of these together make a more reliable forecast.

VI. HOW HEAT IS PRODUCED (Pages 196–220)

Winter is the best time to introduce this subject, though the material may be used to answer questions that arise any time. Some examples of ways in which fifth-graders have initiated problems which used this material for their solution might be suggestive to teachers.

One group came to school after Christmas begging to be allowed to study chemicals. Some of them had chemical sets which they had received for Christmas. Asked why they wanted to study chemicals, they said, "We want to see things fizz." The teacher

realized that the play element was the stimulating motive, so she said, "What do you know about chemicals?" The children gave their ideas, consisting mostly of, "You put things together and they explode." "When I poured two liquids into a test tube they turned red." "You can make invisible ink and it turns black when it's heated." "You put a powder and liquid together and they foam."

The teacher questioned, "Do chemists put things together just to see them foam or pop or change color?" The children replied that chemists were trying to find out something. "Something that will help people," one boy remarked.

When asked what they wanted to find out, the questions were something like this:

1. Why did the powder and liquid foam?
2. Why did the invisible ink turn black when heated?

The teacher then led the discussion toward common chemical reactions with which we are all familiar. She asked, "Have you seen your mother mix anything that foamed?" Immediately, a child said, "Soda and sour milk." "What do you suppose happened?" As a result of the discussion, the children were ready to start experimenting with the materials mentioned on page 207. Another group asked the question "Why does smoke make a shadow?" This involved a discussion of the cause of shadows, with the conclusion that some object blocks the light rays. Then smoke must be made of something that does not allow light to pass through it. This led to the question, "What is smoke?" The children used a candle to produce smoke. They found that a lighted candle smoked when it was blown by wind. They captured some smoke on the bottom of a glass jar by touching it to the top of the flame. The children immediately called it "soot." Where did it come from? Out of the flame. From the burning candle. But the candle was white and the flame blue and yellow. Then there must have been a chemical change. What was the black substance? At this point the teacher suggested reading at the bottom of page 201. The experiments which followed helped solve the problem.

The topic might also grow out of, or integrate with, a social studies unit on fuels or countries producing those fuels.

In a city where there is a great deal of soot, the topic might be introduced by the problem of how soot could be partly eliminated.

The most natural way to introduce the subject is by asking "How do we keep warm?" No matter what kind of fuel we use, the chemical element which produces heat is largely carbon. As an element, carbon is a black, solid, insoluble substance. Soot is carbon. Soot remains on top of the snow instead of dissolving and running away. Yet soot, if it could be conserved in some way, is fuel.

The value of a fuel is dependent upon several factors. The percentage of carbon it contains is, of course, important. The temperature at which the fuel will ignite—the kindling temperature—is also important. The availability, cost, and cleanliness of the fuel are also important. All of these are practical problems we must solve in heating our homes.

Science Concepts:

1. Fuel is anything which is burned to produce heat and other forms of energy.
2. Wood, coal, oil, gas, and coke are fuels used by different people.
3. Some fuels are better for one purpose, while some are better for others.
4. Carbon is the substance in fuels that burns.
5. Carbon is a black, solid, insoluble substance.
6. Charcoal is nearly pure carbon.
7. Artificial gas is made from soft coal.
8. When carbon burns, it changes its characteristics.
9. When carbon burns, it unites with oxygen to form carbon dioxide.
10. Carbon dioxide is a colorless, tasteless, odorless gas that puts out a flame.
11. Carbon dioxide is produced when an acid and a carbonate are put together.
12. Fire extinguishers have an acid and a carbonate in them which produce the carbon dioxide to put out a fire.
13. Carbon monoxide is a poisonous gas produced when there isn't enough oxygen present during burning.
14. One should never run a car engine in a closed garage or lean over the exhaust.

15. One should never sleep in a closed room where a fire is burning.
16. Fresh air should be supplied at once to a person who has been overcome with carbon monoxide.

Problem A. Why Do Fuels Produce Heat? (Pages 198–204)

Suggested Activities:

Make a collection of fuels that are used in the community. The experiment suggested on page 200 may be done in the schoolroom if the materials are available. Any experiment involving fire should be done on a glass- or metal-topped table or on a metal tray. Use pieces of the fuel about the size of a walnut. Lay them above a flame on a piece of wire netting placed on a metal support or two bricks. Canned heat or an alcohol lamp will do just as well as a Bunsen burner. Time the rate with which each fuel catches and burns. Notice other characteristics of the fuel, such as sputtering, production of unpleasant gases, or tar.

Most children have the misconception that charcoal is burned wood. Actually, burned wood is nothing but ashes when the carbon is completely burned. The experiment on page 202 will demonstrate this fact.

If test tubes and a Bunsen burner are available, the following experiment will reveal more. Put a pine splinter in a test tube. Heat in the flame, moving it back and forth to prevent breaking the tube. Always keep the mouth of the tube pointing *away* from anyone.

In a few minutes, moisture will appear, then a thick white cloud will pour out of the tube. If you hold a flame near the cloud, something will ignite, showing that a combustible gas is being driven off. This gas has both carbon and hydrogen in it, and is similar to the artificial gas made from coal. The gas is invisible but water droplets are coming out of the wood so fast that they make a cloud.

Pitch will run out in the tube and there may be an odor of ammonia. A little sulphur may appear on the sides of the tube. All of these products are the result of chemical changes taking place in the wood as it is heated. Children should notice and discuss

what is happening. They should learn that the wood contains all these things, and that chemical changes are being produced by the heat.

Another simple way to produce carbon and study combustion is with a candle. Light a candle and let the tip of the flame touch the bottom of a glass jar. Soot will be deposited on the glass.

Ask the question, "Where did the carbon come from?" Obviously it came from the flame. But the flame didn't look like carbon. Here again is a wonderful chemical change.

Problem B. What Happens to Carbon When It Burns? (Pages 205–210)

What burns in a candle? The wick? The wax? Try to burn wax. It just melts. The wax has to melt and become a gas before it burns. This gas has carbon and hydrogen in it. If there is enough oxygen present around the flame, the carbon is completely united with oxygen to produce carbon dioxide. The flame is almost colorless or blue. The yellow and red flames contain particles of unburned carbon which are glowing like the coals in a fireplace. When you touch the flame with a cold glass, the carbon is deposited on the glass.

To prove that it is a gas and not the wax or wick which burns, blow out a candle and quickly hold a lighted match near it. The flame will leap to the wick. Insert the end of a fine glass tube in the colorless cone of unburned gas around the wick of a burning candle. You can light the gas at the end of the tube. The wick is used in a candle to carry the melted oil and raise its temperature until it vaporizes. Of course the wick chars and burns as the candle burns down.

The experiment on page 204 is very simple to do—and exciting. It too may be done with a test tube, using a cork with a glass tube through it for the gas to come out of.

As the coal heats, by-products will be produced as in the case of the wood. These by-products are used commercially for so many things that they are worth discussing. Dyes, perfumes, medicine, and now even nylon hose are made from coal and its by-products. A chart made to show the products of coal is very

interesting. A bulletin board showing the origin of coal, its stages from decaying vegetation in a prehistoric swamp, to peat, lignite, bituminous, then anthracite coal, and the ways it is mined, may be used as a summary. Information for the chart may be found in an up-to-date encyclopedia.

The experiment on page 205 helps children to better understand chemical change. They know that fire needs air to burn. They may have learned that something is taken out of the air when fuel burns. They may think of it as being "burned up." Here they discover that burning is not a destruction of carbon but a changing of form. The carbon unites with oxygen to form a new and different substance. The carbon isn't destroyed; it just can't be seen.

This concept of the existence of oxygen as a substance may be made more clear by preparing some. This isn't difficult to do. Get a little sodium peroxide, or ozone. A cube of ozone is easy to use and may usually be bought at a drugstore. Handle it with forceps, or in a spoon, as it will burn the skin if it gets damp. Put the cube or a teaspoonful of the peroxide in the bottom of a quart fruit jar. Pour about one-fourth cup of water into the jar. It will react immediately to release oxygen. Cover the jar with a piece of glass until the reaction has ceased. Test the gas by thrusting the glowing end of a pine splinter into the jar. The splinter will burst into flame and burn brightly.

If children ask why the splinter has to be glowing, the teacher may need to explain that for carbon to start to unite with oxygen, it must be hot enough to glow. That is why we use matches to light a fire. Boy Scouts learn to raise the temperature of wood by friction. Indians used two pieces of flint. Our pioneer ancestors used a piece of flint and steel. Every combustible substance has its own kindling temperature. Paper has a lower kindling temperature than wood, wood than coal. A match is tipped with phosphorus and sulphur, both of which have low kindling temperatures.

The experiment on page 207 shows that the reaction of *carbon dioxide* is just opposite to that of oxygen. Oxygen supports combustion because combustion *is* the uniting of carbon and oxygen. Since this union produces carbon dioxide, the chemical bond is already made, and there is no more free oxygen to unite with the carbon in the splinter.

Vinegar and soda are used in the story for producing carbon dioxide because they are harmless. It would be well for the teacher to make a carbon-dioxide generator similar to the one at the top of page 208, using marble chips and hydrochloric acid. More of the gas will be produced in this way.

In making the fire extinguisher, be sure to hold the cork in place as you turn the bottle over. Otherwise, the gas will push the cork out instead of coming out of the tube.

When fuel burns where there is insufficient oxygen to completely combine with the carbon, the poisonous gas, carbon monoxide, is formed. During the winter hardly a day passes that we don't read of cases of CO poisoning. Usually this is due to ignorance of how the gas is formed.

A carbon atom is chemically capable of combining with two atoms of oxygen to form carbon dioxide. CO_2 is a stable compound which does not unite readily with most other substances. When insufficient oxygen is present during combustion, some of the carbon atoms will unite with one atom each of oxygen, forming carbon monoxide. This leaves an unsatisfied chemical bond on the carbon. When carbon monoxide is taken into the lungs, the unsatisfied bond of the carbon unites with the hemoglobin of the red blood corpuscles.

In normal respiration the red blood corpuscles unite with oxygen. They carry the oxygen to all parts of the body, where it is used. If the corpuscles unite with CO the body cells suffocate. Giving oxygen to a person who has been overcome with CO causes the CO to release its hold on the hemoglobin and form harmless CO_2.

Children should know the ways CO is likely to be formed and how to avoid these situations. Also first-aid measures should be taught. If science is worth anything, it should teach children how to be safe and healthy.

Problem C. In What Other Ways Do We Obtain Heat? (Pages 211–213)

With all of the new ways of producing heat that are being discussed at the present time, even fifth-grade children need to know a little bit about them. Nearly every home has some appliance

using electricity to produce heat. All of these work on the same principle—that resistance to the flow of electricity produces heat.

The experiment on pages 211–212 will work if two new 6-volt dry cells are used and the steel wire is fine enough. The finer the wire, the more it resists the flow of electricity.

Children may ask about heating appliances that use neither electricity nor fuel. A "cold wave" permanent and a chemical heating pad are examples. To demonstrate the source of heat in these, let the children feel the flask in which carbon dioxide is being produced. Though they start with cold vinegar and soda, the flask becomes warm. Heat is produced by a chemical reaction. Heat is merely the motion of molecules, and the faster they move the more heat we feel. It is something like the heat produced by rubbing two things together. Children may demonstrate by rubbing their hands together.

Problem D. How Do Our Bodies Keep Warm? (Pages 214–220)

This problem continues the uses of carbon, and applies the principle of chemical change to children's own bodies. It also builds toward the large concept of the carbon cycle. In all of these experiments, let the children *discover* for themselves that foods contain carbon, and that those containing much carbon produce more energy than those containing little carbon.

If the experiment with foods is done in test tubes, it will be easier to see what is happening as they are heated. Starch and sugar will produce a gas which can be burned. The children may generalize that wood, coal, and foods all have gas and carbon in them; also that they all come from plants.

When they discover that CO_2 is released in breathing, the children should be able to conclude that respiration is similar to the combustion of fuel. Be sure they realize that the combustion in the body is slow, much too slow to produce a flame. Children have been known to worry about the fire in their bodies, after learning that food produces heat in the body.

The limewater used in the test for CO_2 is made by pouring water over lime and allowing it to stand in a corked bottle. When lime-

water is needed, filter some of the solution into another bottle. Some of the lime will have dissolved in the water. The solution should be clear.

When CO_2 flows through limewater, it combines chemically with the lime to form calcium carbonate ($CaCO_3$). $CaCO_3$ is insoluble and makes the limewater look milky. The $CaCO_3$ soon settles to the bottom.

The diagram at the bottom of page 220 may be expanded to make a bulletin board, and illustrated with pictures. It may be used to make a summarizing chart by listing different kinds of environments where this oxygen-carbon carbon-dioxide relationship exists; as for example, a pond, a schoolroom with plants and children, a meadow with cows eating grass.

VII. THE WORK OF THE BODY (Pages 221–228)

This topic very naturally follows the problems on food but it may be introduced in other ways.

Children of this age are very curious about their insides. They ask numerous questions about how their hearts or lungs look. They often bring dead animals to the science class, and ask to have them cut open. Even the girls are curious about the internal organs of a bird or a squirrel which the teacher may agree to "open" after school. When children are allowed to watch a dissection if they want to do so, they nearly all come.

While we do not recommend dissection in a children's science class, experiences like this make it evident that children are very curious about the functioning of the living machine, if it is presented in the right way.

The body may be compared to a machine, if you wish to use that device, but the plain truth is interesting enough without embellishing it, and the analogy is not scientifically correct.

Science Concepts:

1. Food has to be changed before heat and other forms of energy can be produced.
2. Food is prepared for use in the body by digestion.

3. The digestive system consists of the mouth, esophagus, stomach, and intestines.
4. Digestive juices produced by the organs of the digestive system mix with the food and digest it.
5. The digested food enters the blood through the walls of the small intestines.
6. The blood vessels carry the food to all parts of the body.
7. The heart, arteries, veins, and capillaries make up the circulatory system.
8. The heart contracts or beats and pumps the blood through the body.
9. The heartbeat can be felt in the pulse.
10. The blood has red and white corpuscles in it.
11. Red corpuscles carry oxygen. White corpuscles destroy bacteria.
12. Oxygen gets into the body by way of the respiratory system.
13. The nose, windpipe, and lungs are parts of the respiratory system.
14. The muscles around the lungs make one breathe by contracting and relaxing.
15. The food carried by the blood and the oxygen carried by the blood unite in all parts of the body to produce energy.
16. Normal body temperature is about 98.6°.
17. To keep well, one should observe these rules:
    a. Get rid of waste.
    b. Eat wholesome food—
        (1) protective foods,
        (2) enough, but not too much.
    c. Care for the circulatory system.
    d. Care for the respiratory system.
    e. Do not expose yourself or others to infectious or contagious diseases.

Problem A. How Is Food Digested? (Pages 221–224)

If the children have had the experiments with foods given in The How and Why Club, they will know that to be absorbed

through the intestinal walls, food must be made soluble. If they haven't had these experiments, the teacher should look them up and let the children do them. Suggestions are given in the manual as to how to carry them out. This story enlarges upon and adds to those concepts.

The first step in digestion is mastication. The mouth breaks up and mixes the food with saliva, and digestion of starch begins. Making food soluble, such as changing starch to sugar, is just part of the process. Cane sugar is soluble, but it has to be reduced to glucose before it goes into the blood. This happens in the small intestine. The same is true of the digestion of proteins in the stomach. They are partly broken down by the enzymes in the gastric juice, but final digestion takes place in the small intestine. So all parts of the digestive system play important roles in digestion.

The main concepts for children to gain will probably come as a result of their interest. If a manikin, model, or good chart is available, the children should be allowed to examine it, and satisfy their curiosity. Of course the liver, gall bladder, and pancreas are parts of the digestive system, but the teacher need not introduce them unless the children ask about them. The purpose is to give children a simple story of digestion which will help them see reasons for eating wholesome food and establishing regular habits.

The experiment on page 224 is a simple osmosis experiment. Teachers will recall the classic osmosis experiment in which molasses is put into a thistle tube that has a membrane stretched over the large end. When the tube is lowered in water, water passes through the membrane into the molasses and molasses passes through into the water. Because the water is less dense than the molasses, it goes through the membrane faster than the molasses does and the solution rises in the tube.

Doing the experiment with an egg is simple and needs no complicated apparatus. The main difficulty is in keeping intact the egg membrane at the end which is to be placed in water. A needle may be used to pick away a bit of the shell. At the other end, try to make a hole to fit the tube. The tube should be at least a foot long. If you have a longer one, use it. A transparent drinking straw may be used if a glass tube is not available. Osmotic pres-

sure may send the liquid as high as a room, if nothing happens to it. Sometimes air striking the egg will cause it to seal the tube before the solution has gone very high. A fine wire may be pushed down the tube and the seal broken.

Osmosis helps to explain how dissolved foods pass through the walls of the villi of the small intestine into the capillaries. Osmosis is the interchange of liquids of unequal density through a semi-permeable membrane. It is the physical process by which all liquids in living things pass through cell walls and thus through tissues and into organs. Technically, this process in the intestine is known as *dialysis*. It is not important for children to know these terms.

Problem B. How Do We Keep Well? (Pages 225–228)

Regular habits of eating and elimination are so easily established in childhood that the teacher should make an effort to make this problem interesting to children. Some children may have had appendicitis. They will want to know where the appendix is and what it is for. Many of them have had digestive disturbances and have had to take laxatives. If they can be helped to avoid these common ills by establishing regular habits, this topic will be worth while.

To arouse an interest in choosing well balanced meals, children may make charts or bulletin boards, of good meals and poor meals. The National Dairy Council gives a great deal of teaching material on meal planning. One packet contains colored pictures of foods, printed on cardboard. The pictures have tabs by which they may be stood up when cut out. One fifth grade divided into committees, each of which set a table with a balanced meal. Another class wanted to dramatize meal planning and buying, with serving as a culminating activity. The learnings were practiced in the school cafeteria. Any activity which makes children *want* to practice good health habits is worth while.

If the school has a common lunchroom, the children may make a group study of the menus. They may investigate prices of different foods having the same food values. One group carried out an in-

tegrated unit on foods in which they traced the sources as a part of their social studies. They figured prices as a part of their arithmetic and made posters in their art classes.

VIII. FOOD-MAKING IN PLANTS (Pages 229–245)

The process by which green plants are able to take materials out of the air and soil and convert them into carbohydrates is known as *photosynthesis.* Man has long tried to imitate this chemical miracle in the laboratory, but with little success. He can analyze the finished product. He knows something of the process which takes place in the plant, but the secret of large scale production is still locked in the tiny color bodies, the chloroplasts, of living leaf cells. At the present time bio-chemists think that they may be on the track of this process. The *Science News Letter* for Jan. 10, 1948 reports that through the use of "tagged" carbon atoms, scientists at the University of California are able to trace the course of the CO_2 used in photosynthesis. The atoms are artificially radio-active and can be traced by the use of a Geiger counter. While this information may be unimportant to fifth-graders, the popular material on the atomic bomb has added many new words to children's vocabularies. Comic books are full of half truths which raise many questions.

Briefly, this is the story of what happens in a green plant.

A seed plant (Spermatophyte) has four organs: *roots, stem, leaves,* and *flowers.* Each of these organs has a function to perform. The principal function of the roots is absorption; of the stem, transportation; of the leaves, food manufacture (photosynthesis); of the flowers, reproduction.

These organs perform other functions in different plants, such as: roots, anchorage and food storage; stem, support and storage; leaves, respiration and transpiration. In some plants these different parts may also be used to propagate the plant.

The roots of a plant may be branching or fibrous, depending upon the class to which the plant belongs. Monocotyledons, such as corn, lilies, and grasses have fibrous roots. Dicotyledons, such as beans, geraniums, maple trees, and many other common plants have a branching root system.

Whatever the type of root system, main roots have finer roots growing out of them, called rootlets, and the finest rootlets have tiny root hairs near their tips. Root hairs are so fine that they look like fuzz or cotton. We rarely see root hairs unless we sprout seeds on damp blotting paper. Then the root hairs appear as cottony growths about a quarter of an inch back of the root tips. When a plant is pulled up, the root hairs are destroyed.

Through these delicate root hairs, each one just one cell big, enter all the dissolved materials from the soil which are used by the plant. These materials are minerals. Water is the most needed mineral, both as a solvent for the other minerals and as an ingredient in photosynthesis. Soil solution passes through the walls of the root hairs by the process of osmosis, into the water-carrying cells of the roots (xylem cells), up into the xylem cells of the stem, and finally by way of the leaf stalks (petioles) into the leaves. This transportation system is called the vascular tissue of the plant, and consists not only of the xylem cells but of food-carrying cells (phloem) and strengthening fibers (bast fibers). These fibers can be seen plainly in celery. They give tensile strength to stems and make many plants useful to man.

When the water reaches the leaves, it passes from the veins into the cells of the leaves. Most of the cells of a leaf contain chloroplasts, the workers in the factory. The chloroplasts need another ingredient besides water for making carbohydrates. They need carbon. Carbon is insoluble in water so it cannot be brought in solution from the soil. It has to come into the plant in a soluble form. That form is carbon dioxide. How does carbon dioxide enter the plant?

If you could cut a cross section of a leaf as you would cut a slice of bread and look into the leaf, you would see how CO_2 gets into it. The upper and under surfaces of the leaf, like top and bottom floors, are made of flat cells packed tightly together. These are epidermal cells and contain no chlorophyll. Between these two layers are the chlorophyll-bearing cells (palisade and mesophyll). The palisade cells are just under the upper epidermis and are so-called because they are column-like. The mesophyll cells are more irregular in shape and more loosely put together. They surround the veins. In the lower epidermis, you would see openings

(stomata) with two chlorophyll-bearing guard cells around each. It is through these stomata that air enters the leaf. (See picture page 24.)

In the cells of the leaf, chloroplasts combine carbon from the CO_2 and water from the soil to form sugar and starch. One other factor is necessary to the process. We have the workers, the materials, and a place to work, but no power or energy. Sunlight is the energy.

During the day, leaves are at work manufacturing starch and sugar. The sugar, being soluble, can be transported immediately by way of the phloem cells of the vascular bundles, to all parts of the plant. This sugar solution is the sap. The starch has to be changed to sugar before it can leave the leaf cells. This is accomplished by the process of digestion.

Enzymes in the protoplasm of the leaf digest the starch, changing it to sugar. At the end of a sunny day, leaves are usually full of starch. By morning, the starch is gone. Through the night the starch has been changed to sugar. The following chart may help to summarize these processes:

Process	*Time*	*Place*	*Materials*	*Agent*	*Energy*	*Product*	*By-Product*
Photosynthesis	Day	Cells of Leaves	CO_2 and H_2O	Chlorophyll	Sunlight	Starch Sugar	Oxygen
Digestion	Mostly at Night	Cells of Leaves	Starch and Water	Enzymes (Diastase)	Of Oxidation	Sugar	None
Internal Respiration	All of the Time	Cells All Over Plant	Sugar and Oxygen	Oxygen	Atomic Potential	Energy	CO_2 and H_2O

Oxygen used in respiration enters the plant in the air, not only through stomata, but also by way of openings in the stem (lenticels). The process of internal respiration is essentially the same as in animals. The energy released is used by the plant in carrying on its life processes. Of course all food isn't used in producing energy any more than it is used that way in animals. Some is used

in growth and repair. Other minerals from the soil are added to the sugar to make protoplasm. Besides the carbon, hydrogen, and oxygen of the sugar molecule, nitrogen is the element needed to construct the basic protein molecules. Potassium, sulphur, and other minerals in small amounts are used in building protoplasm and different types of cells.

Science Concepts:

1. Green plants manufacture starch and sugar in their leaves.
2. Green coloring matter or chlorophyll does the work of manufacturing.
3. Chlorophyll uses water and carbon dioxide to make sugar and starch.
4. Water comes into the plant through root hairs on the rootlets.
5. Water and dissolved minerals travel up to the leaves by way of a transportation system.
6. The roots of a plant are the absorbing organs.
7. The stems of a plant are the transporting organs.
8. The trunk of a tree is its stem. It has layers that perform different work.
9. The main layers of a tree are the bark, food-carrying layer, cambium, water-carrying layer.
10. The rings of a tree are the dead layers made in previous years.
11. The branches of a tree are stems that hold the leaves.
12. The leaves of a tree do the work of food-making.
13. Starch and sugar are made in the leaves during the daytime.

PROBLEM A. HOW DO PLANTS GET AND USE FOOD? (Pages 229–244)

Suggested Activities:

If you are in a community where sugar beets or sugar cane are raised, the easiest way to introduce this unit is by a story similar to the one in the book.

Children often have questions about the falling of leaves in autumn or the swelling of buds in spring. Both these activities of

trees are closely linked with food-making in the tree. When photosynthesis slows up in autumn, due to decreased available water supply and the growing of the corky layer between leaf petioles and twigs, leaves begin to change color and die. In the spring with warmer days and increased available water, stored food is digested and used by the buds to produce leaves and flowers.

The unit could be introduced by a discussion of house plants. Their need for light, manifested by growing toward the light, is familiar to most children. The question of why plants need light will start a discussion.

Children sometimes notice the bubbles rising from an aquarium and ask questions about them. The teacher might put one aquarium in the sun and another in the shade, and ask the children if they can explain what happens.

The teacher should make sure that children know the parts of a plant: root, stem, leaves, and flowers. Let them examine the parts of a familiar plant such as a bean plant or geranium. After pointing out the parts of a familiar plant the children should see if they can find the parts of a turnip, a carrot, potato plant, and others that are not so obvious.

The diagram on page 237 is merely to show that the food materials go up through the vascular system, and the dissolved food (sugar) moves down. The vascular tissue contains both kinds of cells.

A simple way to demonstrate the vascular system of a plant is to cut the stem under water and stand it in water in which a little red vegetable coloring has been dissolved. A plant with white flowers such as white sweet peas, carnations, or Queen Anne's Lace will show the pink tint in the veins after a few hours. A stalk of celery is excellent for this demonstration. After the stem has absorbed the red solution, cut a cross section and see how the vascular bundles show up. If you have a microscope, mount a thin section of the stem so the children can see the cells.

To show root hairs, sprout some seeds on damp blotting paper. Oats, wheat, radishes, or corn are good seeds to use. Another good way to see root hairs is to germinate the seeds in a glass jar of sand. Place the seeds next to the glass and germinate them in the dark. The young roots will show root hairs near their tips. Mount a thin

section of the root from the root-hair zone in a drop of water and examine under the low power of the microscope. Root hairs look like cotton to the naked eye.

Try to find a freshly cut tree stump and look for the rings. The live part of the tree is a thin layer just under the bark (sapwood). The rings and pith are all dead wood (heartwood). The heartwood of a tree may be partly destroyed by insects or fungi, and yet the tree may live. However, the heartwood supports the tree and if it is gone, the tree will blow over. Children may see trees that have been "doctored" by being filled with cement. This prolongs the life of a tree much as removing the decayed portion of a tooth and filling it preserves the tooth.

Children should remove the sapwood from a twig and notice the wet, live appearance it has as compared with the heartwood. Ask, "Why does girdling a tree kill it?" "Why does sap drip from a twig broken in the spring?" "How should branches be removed when pruning trees and shrubs?" "Why should we not break branches from trees and shrubs?" Children should be taught how to cut flowers and twigs from shrubs and trees so as not to injure the plants. A sharp knife should be used and a clean cut made, leaving no stubs protruding to decay. Here is a good opportunity to teach the social attitude of respect for property.

Before doing experiments such as those on pages 240–241 in a classroom, the teacher must try them herself, using all safety precautions.

The experiments on pages 240–241 may be done with rubbing alcohol. Chlorophyll is soluble in alcohol, and the heating helps soften the cell walls so that chlorophyll can escape into the liquid. The leaves should be picked after they have been working in the sunshine for several hours. Any kind of leaf will do, though soft leaves such as geranium and nasturtium work a little better than stiff, glossy leaves. The iodine is more easily absorbed. In doing the experiment be careful not to let the alcohol boil over onto the hot wires of the electric plate. Alcohol is very inflammable since it has a low kindling point. If some should spill and catch fire, stand back and let it burn. If no paper or other highly inflammable material is near, the alcohol will soon burn completely and no harm will be done.

In addition to the experiment on page 241, variegated leaves may be used to demonstrate the necessity of chlorophyll to photosynthesis. Variegated geranium, ivy, Coleus, or Wandering Jew have spots with no chlorophyll in them. When tested, these spots will remain unchanged while the starch will show up in the areas that contained chlorophyll.

Children should examine different kinds of fruits to find that the fruits contain seeds. They should watch plants as they bloom and produce fruit to gain the concept that flowers are the organs of reproduction; also to correct the misconception that all fruits are juicy like the apples they eat. A kernel of corn or a grain of wheat, a gourd, an acorn, or a bean pod is a fruit.

When discussing how plants use food, the class should take a trip to look for injuries to trees. Find places where the new bark has grown over the injured part. Notice twigs from which sap is oozing, and try to determine the cause. With a penknife, dig into places along the trunks of trees that have pitch oozing from them. You will often find insects that are eating the sapwood of the tree. If these places are cleaned out and filled with creosote, the tree may be saved.

In the early part of the book, the children learned about the structure of mold. Since mold has no chlorophyll it cannot make its own food. The teacher may ask "What plants do you know about that can't make food?"

The children should go on a trip and hunt for fungi growing on both decaying and live material. In either case, all of the food coming into the mycelia of the fungi must be dissolved. It is absorbed by the process of osmosis.

IX. THE BALANCE OF NATURE (Pages 244–254)

Someone has called the interdependence of living things, "The Maze of Life." Actually the physical environment is just as important a link in this chain of existence as are the plants and animals. The teacher should introduce the idea from time to time as she leads field trips, listens to reports of the children's observations, or carries on classroom activities. Each time a plant or animal is brought into the room to be cared for, the children should

discuss all of the things that are needed to make it live and grow properly. This is a good time to review types of environment and the different kinds of plants and animals found in each. The children may enjoy making bulletin boards to portray these. For example, a large cross section of the edge of an ocean might be drawn. Pictures of the plants and animals one would expect to find in the shallow water near the shore could be pinned in place. A desert scene would show the opposite types of life, while intermediate types might be along a river. While constructing these bulletin boards the teacher should lead a discussion by asking such questions as "How is it possible for an oyster to remain attached to the ocean bottom and still live?" or "How can a fish live in an aquarium where the water is never changed?" or if by chance the only communities you can investigate are in a cubic foot of earth in the schoolyard, "What must the soil contain for so many tiny creatures to be able to live in it?" No matter where you teach, you can find examples of this interdependence between living things and their physical environment.

The experiment on page 245 works well with such water plants as elodea. Be sure the plant is fresh and that the water doesn't contain chlorine. If you have an aquarium in the room, the experiment may be set up in it. Turn the jar over some water plants in the aquarium. Or turn a glass funnel over some plants in the aquarium and invert a test tube filled with water over the stem of the funnel. As oxygen rises in the funnel, it will push the water out of the test tube. When the test tube has no more water in it, lift it out and quickly thrust a glowing splinter into the tube.

Problem A. How Do Plants and Animals Depend on Each Other? (Pages 244–245)

This is a summary and review of the carbon dioxide-oxygen cycle. It attempts to clarify and fix the concept that *all* living things use oxygen in respiration and release carbon dioxide.

This may be demonstrated by sprouting some wheat or oats on cotton in the bottom of a quart jar. After the seeds are placed on the moist cotton, plug the mouth of the jar with a piece of cotton. As soon as the seeds start to germinate, put a lid on the jar and seal

it with paraffin. The seeds will grow a while, then start to die. At this point open the jar and lower a lighted candle into the jar. If several jars are set up at the same time, one can be left unsealed. One may be tipped above a jar of limewater to allow the CO_2 to flow into the limewater. As the seeds germinate, they use the oxygen in the jar and release CO_2. When no more oxygen remains, the plants die. The seeds in the unsealed jar should grow until they use all of the food stored in the seeds. To be able to correct conclusions, several jars should be prepared. It is never scientific to draw conclusions from one experiment.

Problem B. How Do Plants and Animals Live Together? (Pages 246–254)

This story illustrates some of the plant and animal relationships suggested in the last problem. Although the setting is laid in the mountains, the principles discussed operate in any environment.

Children often ask "Why do leaves change color in autumn?" In the lower grades children have too little background to understand the complicated process which causes this change. So we merely tell them that the trees stop growing and the leaves die. Fifth-graders now know something about photosynthesis and chemical changes. They can understand that chemical changes may cause color changes. For the teacher's information the facts are as follows:

The green color of chlorophyll is due to the presence of pigments, chlorophyll (green), carotin and xanthophyll (both yellow). The green masks the yellow when the leaves are alive and growing. In some leaves and in many flowers are other pigments, anthocyanin pigments, that account for the red, mauve, blue, purple, and violet colors. While chlorophyll is not soluble in water, these anthocyanin pigments are. The red coloring of beets is an example. Intense light and low temperatures favor the development of anthocyanin pigments. Some leaves have these pigments when they are young and lose them as they grow older, while others reverse this process. In the leaves that are red in autumn, excess sugar is often present.

As cold weather approaches, a corky layer of cells grows across

the petiole of the leaf, cutting it off from the twig. In some trees this layer is very brittle when it has formed and the slightest breeze will detach the leaves from the tree. Maples are examples. In others, like the white oaks, the tissue (abscission layer) is tough and holds the leaves to the twigs unless blown by a hard wind. That is the reason one often sees oak trees covered with dry, brown leaves in the winter.

Activities which will help to answer children's questions may follow the extraction of chlorophyll from green leaves. If the chlorophyll and alcohol solution is allowed to stand a few days, the green will disappear and yellow remain. Chlorophyll is unstable when it is not working. This is what happens in the leaves.

Children may gather red leaves and boil them in water to extract the red pigment. An interesting fact about many of these red anthocyanins is that they may be changed to blue by adding an alkali to them. Try putting soda into some of the red liquid. Similarly, the blue anthocyanin from many flowers is turned red by adding acid. This explains the color changes in some flowers grown in different kinds of soil. Blue cornflowers, if boiled in water, will turn red if acid is put into the flask with them. These are, of course, all chemical changes similar to the changes in litmus paper but the chemical involved is not the same.

If porcupines live in your region, a field trip to a woods will probably reveal a number of trees similar to the one on page 251. Porcupines are sluggish, harmless rodents that climb trees and gnaw the bark for food. If the tree is girdled, the part above the girdled area will die. The presence of porcupines in a woods may be detected by these dead topped trees. Seldom are there enough porcupines in a region to do much harm.

If children have the misconception that porcupines throw their quills, the idea should be discussed and facts gathered to prove or disprove it. It is a fine opportunity to teach the scientific attitude that one should not draw conclusions with insufficient evidence. Instead of saying "Porcupines do not throw their quills," the teacher may say "I wonder if that is true." A storm of pros and cons may meet this statement. The teacher may then say "You all have ideas, but in science we must have proof. How can we prove whether or not a porcupine throws its quills?"

Few teachers will be so fortunate as one who had a young porcupine brought into the schoolroom. It had been found under a bush on the grounds! The teacher was a bit nonplussed but her training stood her in good stead and donning a pair of gloves she put the frightened animal into a cage. The children were wary at first, but when they discovered that the porcupine, cowering in the back of the cage, was more frightened than they, they put water and food into the cage. The porcupine reacted much as a squirrel would, soon becoming quite tame. It would come out of the box placed in the cage for shelter, to the front of the cage, when anyone approached. It made queer little noises, begging for food. Some of the quills dropped out, as hair is shed, and were examined under lenses.

When a dog was allowed to approach the cage the children saw "Porky" raise his quills threateningly, but none were "shot." In time he was petted with a gloved hand, to prevent the barbed quills catching in the flesh, and the children saw how a few were pulled from the skin when a piece of cloth was drawn across the quills. At the end of two weeks "Porky" was so tame that releasing him became a problem. He was taken to the country and carried to a woods. Like a pet dog he tried to follow his human friends.

Children who can't observe live porcupines can usually examine quills and pictures. They will have to read for further information.

There are many kinds of boring insects to be found in trees. Some live on the cambium under the bark of live trees, killing the trees. Some live on dead wood. Wherever woodpeckers are working, you will find larvae and pupae of insects.

Besides the boring insects, the leaves of trees, shrubs, and many garden plants harbor insect larvae. Some of these, such as caterpillars, eat the leaf. Some, such as aphids, suck the sap. Some, called skeletonizers, eat all but the veins of the leaf, leaving lacy skeletons. Some, leaf miners, live between the upper and lower epidermis of the leaf, making characteristic patterns specific to each kind of leaf and insect.

So numerous are the species of insects having these relationships with plants that books are available on each group. It isn't important for children to be specific. But it is interesting to them to

realize that one bush is like a city with many inhabitants living in and on it. The teacher may hint that within twenty yards from where they are standing are thousands of examples of the relationships suggested on page 254, and give the children ten minutes to see how many they can find. Let them pace off the distance in radiating lines from the center, and go to work. They may work in pairs with the teacher going from one pair to another, suggesting or showing examples where the children are having trouble getting the idea. They may see birds eating some of the insects. In addition to woodpeckers, nuthatches, chickadees, kinglets, warblers, brown creepers, and many others eat insects found on plants.

X. THE SEASONS (Pages 255–265)

We are told that two of the most difficult concepts for children to learn are those of time and space. They are so abstract. Therefore, teachers need to use every device they can think of to make meaningful the terms we use in connection with time and space. The material in this chapter is intended to help clarify the reasons for our time divisions.

Children often have questions such as, "Why is March 21 the first day of spring?" or "Why do people say we are likely to have storms around September 21?" Since discussions leading to questions on seasons may arise at any time, the information given here may be used any time.

Science Concepts:

1. The earth's axis is the imaginary line on which it turns.
2. The turning of the earth on its axis is rotation. Rotation takes twenty-four hours.
3. One rotation of the earth causes a day and a night.
4. The places on the earth at the ends of the axis are called the poles.
5. Imaginary lines on the earth help us to tell time.
6. A year is the time it takes the earth to travel around the sun. This is called revolution.
7. The earth rotates 365¼ times as it revolves once.

8. Leap year is the year to which we add a day each four years, instead of having an extra one-fourth day each year.
9. The equator is an imaginary line around the globe half way between north and south poles.
10. The seasons are caused by the inclination of the earth on its axis as it revolves.

Problem A. What Causes Day and Night? (Pages 256–258)

Suggested Activities:

Although the children have learned what causes day and night in the lower grades, they should do the demonstrations again for review. Use a globe and light. Be sure that the children don't think the earth's axis is a rod. The newer, free-moving globes eliminate the rod. Notice that the globe is tilted instead of perpendicular. Also notice that the light covers only half of the globe at a time. Notice the direction of rotation from west to east. It helps children to identify themselves with the earth if they all pretend that they are "earths" and rotate. When their backs are to the light, it is easy for them to understand why it is night, and so on.

Problem B. What Makes a Year? (Pages 259–260)

A child should carry the globe around the light to demonstrate the path of the earth around the sun. Discuss the fact that the earth is just one planet of the sun's family. As the globe revolves it also rotates.

Sometimes a child who doesn't get this idea of rotation and revolution will have it clarified by pretending that he is the earth. Let him turn around slowly to illustrate the rotation on an axis. Then have him rotate as he walks around the light.

Spinning a coin, a top, or a gyroscope are all simple ways of helping children to understand rotation and revolution. These objects will move along a table as they spin, making two movements similar to those of the earth. Spinning an orange helps to illustrate an imaginary line, the axis. All of these motions are counterclockwise.

Problem C. What Causes the Seasons? (Pages 261–265)

After simply revolving the globe around the light, call attention to the tilt of its axis. First let the children place the globe with the axis perpendicular. Demonstrate by rotating it that the days and nights would always be equal if the earth's axis were perpendicular to its orbit.

Then tilt it 23½° to demonstrate each of the positions shown on pages 263–265. Only by an actual demonstration will this be made clear to children.

To clarify the concept that slanting rays give less heat energy than direct rays, the following demonstration may be used. Darken the room if possible. Hold a flashlight so that the light falls directly on the blackboard, forming a round bright spot. Then tilt the flashlight so that the rays cover a larger area with more diffused light. The children may hold their hands in the spots and feel the difference in heat. Remember that radiant energy, or light, is not heat until it strikes an object and activates the molecules. Consequently, the more intense the light, the more heat is produced.

XI. BONES, MUSCLES, AND NERVES (Pages 266–291)

The material in this unit was accidentally introduced to one group when the teacher broke her ankle. She came to school after a few days with a cast on her leg. The children had questions like, "Why do you have to wear a cast?" "How does a bone grow together?" "What makes bones grow deformed?" "Why do you have to take calcium tablets?"

Another group was much interested in the operations being performed at intervals on the legs and feet of one of the boys who was crippled as a result of infantile paralysis. When the boy returned to school after a visit to the hospital, he asked many questions such as, "Why were the bones of one boy in the hospital so brittle that he would break them if he fell down?" and "Why did they hang a weight on my foot?"

Fortunately, accidents don't always happen to introduce problems. If accidents *do* happen, use them to teach how the body

works. Accidents to human beings or other animals should always be utilized in teaching safety.

Sometimes a bone is found on a field trip. It may be from a cow, horse, or other animal. It will stimulate questions.

Science Concepts:

1. Do not move a person with a broken bone until a support has been put under it.
2. A cast keeps the ends of a broken bone in place so they will grow together straight.
3. Bones are living, growing parts of one's body that give it support.
4. Bones need calcium to make them hard, and milk has calcium in it.
5. All of the bones together make up the skeleton.
6. The skeleton consists of the head, neck, trunk, spinal column, ribs, arms, and legs.
7. Good posture is necessary for good health.
8. Bones are joined together at the joints.
9. Ligaments hold bones in place.
10. Shoes should fit and have low heels.
11. One should take care of his hands and feet.
12. Muscles move the bones.
13. Muscles do their work by contracting and expanding.
14. Some muscles can be controlled; some muscles cannot be controlled.
15. Muscles need food, oxygen, exercise, and rest.
16. Muscles may be injured by bruising, straining, and spraining.
17. The nervous system controls the body.
18. The brain is the center of the nervous system. The spinal cord and nerves carry messages to and from the brain to all parts of the body.
19. A message that does not travel to the brain to be completed causes a reflex action.
20. Habits are formed in the nervous system by doing the same thing over and over again. One should form desirable habits.

Problem A. How Do Bones Work? (Pages 266–277)

Contrary to adult ideas, children are fascinated by skeletons. They bring bones and skulls of animals to school and examine them with curiosity rather than disgust. If the teacher can procure parts of skeletons, even those of a chicken or fish, they will help children understand their own skeletons.

The long bones in the legs and wings may be studied and the joints examined for their articulation. Let the children feel their own elbow joints as they bend their arms. Feel the two bones in the forearm as it is turned. A joint from a rabbit or lamb leg is very similar and may be obtained from a friendly butcher.

The teacher can get a shank bone from the butcher and have him cut it to show the marrow. She may get a piece of a backbone, also, which will show how the vertebrae fit together.

If any child has a baby brother or sister whose bones are still soft, opportunity is provided to discuss what the baby needs in its food to make the bones hard. The child may ask about the "soft spot" in the skull. The skull of a cat, dog, or rabbit will help demonstrate the way skull bones are put together.

Let the children feel their backbones as they bend and turn. Discuss and demonstrate correct posture. Shadowgraphs on a sheet will help each child try to stand and sit correctly. X-ray pictures may be borrowed from a doctor, to show the ribs, pelvis, and skull.

Charts showing the bones of the feet may be obtained free from several of the orthopedic shoe companies. If possible, the children should look at their own feet in an X-ray machine.

Impressions may be made of the children's feet by having them step barefooted on carbon paper over typing paper. This will show whether or not they have strong arches.

The purpose of this whole unit is to help children grow strong, straight, and well. Any activities that will interest them and accomplish desired results should be used.

Problem B. How Do Muscles Work? (Pages 278–282)

Most children don't realize that lean meat is muscle. A chicken

leg (drumstick) is excellent to demonstrate how the muscle is fastened to the bone by tendons. Children sometimes get a chicken or turkey foot and pull the tendon to flex the toes. If they feel their own hands and wrists as the fingers are moved, they can feel the tendons pulling muscles.

As one clenches his fist, he can feel the muscles of his arm contract and relax. As he stands on his toes, he can feel the muscles in his legs contract.

Problem C. How Do Nerves Work? (Pages 283–291)

The spinal column of a fish is good to use to show the spinal cord and nerves branching from it. Good charts should be borrowed for illustration. Let children trace messages to different parts of the body, in a fashion similar to the one interpreted on page 288. They may list good habits and discuss ways of forming them.

One group of children discussed and worked out ways of remembering important things. Several of them were habitually late at 1:00 o'clock. The teacher finally sat down with them and asked them to analyze the problem, "How can we learn to be on time?" They gave various reasons for being late, such as, "I forgot my band instrument until I was half way to school and had to go back," "I forgot my library book," "I forgot the ten cents for the puppet show." The solution finally resolved itself into suggestions of ways to remember. These included "Write it down; then you don't forget." "Put it with your coat as soon as you get home." "Stop and think 'remember your book'; it's like writing it in your brain." Tardiness ceased after a few days of repetition of these ideas. New habits had been formed. Participation in such a discussion results in better attitudes on the part of the children. It is a shared activity in which they join wholeheartedly because they see the reasons for it.

XII. CONSERVATION OF NATURAL RESOURCES (Pages 292–303)

The terrible results of waste have impressed themselves upon us in the last few years. If teachers aren't informed concerning the

facts of the results of forest fires, erosion, and destruction of wild life, they should read one of the excellent books recently published. See reference list.

The way the subject is introduced depends upon the region in which it is taught. Every region is trying to repair the damage done to its own resources. A brief survey of these resources would be a good way to start. This chapter might be used following the one on interdependence of living things. Conservation is man's attempt to undo the harm he has done in upsetting the balance of nature. Though the chapter deals with living things, it affords a good opportunity to discuss the relation of soil to plant and animal conservation. Without soil there would be no plants nor animals.

A map could be made of the resources of the United States in connection with social studies. Much material in the way of bulletins, charts, pictures, and slides is available through the United States Department of Agriculture.

Science Concepts:

1. The materials that were in the country before men lived here are natural resources.
2. Forests are one of our most valuable resources.
3. The United States National Forestry Service is trying to preserve our forests by fighting fires and replanting trees.
4. Wild animals are natural resources that should be conserved.

PROBLEM A. HOW CAN WE HELP WITH CONSERVATION? (Pages 292–303)

A boy asks a question, "Why do they have a season on duck hunting?" or "Why can't hunters kill does?" We discuss what happened to animals when there were no game laws. These do not yet affect the boy and he is interested only because his father hunts.

There are many ways, however, in which children can aid conservation. If they live in the eroded region of the west, they can join in a reforestation program. In many places the state departments will provide seedling trees to schools that will plant them.

Fifth-graders can sprout seeds of trees to be planted where they will help hold soil. Then they may care for the young trees.

One group found that the yard around their school was being gullied and washed away. They got some help from the local representative of the United States Department of Conservation, and stopped the erosion by proper planting. The United States Department of Agriculture has a great deal of material on soil conservation, most of which is free to teachers.

Conservation in a small way can be practiced when collecting frog eggs or any other live material. Take just what you need. Return any that you are through studying and that you do not wish to care for.

Answers to Questions on Page 302: (If desired, these questions may be used as problems to introduce the topic.)

1. If the tent caterpillars are just starting, a spray will help. After they have spun their webs, the spray won't help. If not too many branches are infested, they may be cut and burned. Torches are used to kill those in large trees, but they should not be used by children without the help of an adult.

2. Only as many eggs as you can care for. After the eggs hatch, any tadpoles you don't have room for should be returned to the pool.

3. By helping tide birds over the stormy season when food and water are almost impossible to get, you save the lives of many helpful birds.

4. By being sure that all camp fires are made in a clear spot, with no underbrush near enough to catch fire. By clearing the spot down to the sand so that there is no decaying vegetation to catch fire and smolder. By watching to see that no sparks fly into leaves or underbrush. By putting the fires out with sand or water, leaving no live coals. By reporting to a forest ranger any smoke or fires you may see that are unattended. By never throwing a burning match on the ground where any dry inflammable material might start a fire.

5. Only those wild flowers that are growing in profusion and no rare kinds. Pick only a few from each plant, always leaving some to produce seed.

6. Report it to a forest ranger.

7. Since does bear the young, killing them indiscriminately would in time eradicate deer. However, when a region has too many deer, hunters are sometimes permitted to kill does.

XIII. HONEY-MAKERS (Pages 304–325)

This chapter is a continuation of the problems taught in the fall on interdependence between plants and animals. At that time the children probably had questions about the activities of the bees. A summary of the characteristics of honeybees may help teachers in presenting this unit.

Honeybees belong to the order of insects known as Hymenoptera. There are nearly thirty classified orders of insects. Of these, eight or ten are the most common. These are classified according to the structure of their bodies. Because the wings in each case are characteristic, the name of the order is usually descriptive of the kind of wings. Of course children shouldn't be taught these technical details, but it is helpful for a teacher to know them so she can identify the insects children bring in. In many cases, insects belonging to different orders so closely resemble each other as to fool us unless we examine the wings, mouth parts, and legs.

The eight most common orders of insects are:

Order	*Meaning*	*Mouth Parts*	*Some Insects Belonging to It*
1. Hymenoptera	Membrane wings	Sucking and biting	Bees, Wasps, Ants
2. Diptera	Two wings	Rasping and sucking	Flies, Mosquitoes, Gnats
3. Coleoptera	Shield wings	Piercing and biting	Beetles, Weevils
4. Lepidoptera	Scale wings	Sucking	Butterflies, Moths
5. Orthoptera	Straight wings	Biting and chewing	Grasshoppers, Crickets, Cockroaches, Mantids, Walking sticks, Katydids
6. Hemiptera	Half wings	Piercing and sucking	True bugs, Stinkbugs, Bedbugs, Waterbugs
7. Homoptera	Same wings	Piercing and sucking	Cicada, Aphids
8. Odonata	Toothed	Biting	Dragon flies, Damsel flies

The first four of these have complete metamorphosis. This means that they have egg, larva, pupa, and adult stages in the life his-

tory. The last four have incomplete metamorphosis; that is, egg, nymph, and adult. Each order has other characteristics also, which may be found in some of the references.

The characteristics of bees which interest children are those modifications of structure that enable them to do their work. The following chart summarizes the work of each member of the hive:

Member	*Sex*	*Duties*		
Queen	Female	Leads swarm		
		Lays eggs		
Workers	Undeveloped females	Gather	Nectar	
			Pollen	
			Propolis (bee glue)	
		Manufacture	From nectar	honey
				wax
			From pollen and nectar	bee bread
				royal jelly
		Build hive	Storage cells	
			worker size	
			Brood cells	
			worker size	
			drone size	
			queen cells	
		Care for queen		
		Feed drones		
		Nurse young bees		
		Care for hive	Clean it	
			Repair it	
			Ventilate it	
		Select	New site for swarm	
			New queen	
Drones	Male	One mates with queen		
		Others have no function.		

Workers are undeveloped females in the sense that their reproductive organs do not ordinarily function. However, workers have been known to lay eggs when the queen was killed and no other queen was available. Of course, the eggs were not fertile and the worker did not serve as a queen. A worker has well developed mouth parts, a long tongue with which to obtain nectar, and biting mandibles used in biting wax. The wax is manufactured in certain workers' bodies through a chemical change in nectar. It is said that it takes enough nectar to make fifteen pounds of honey to produce one pound of wax.

Workers have well developed stingers, a modification of the ovipositor.

The order Hymenoptera is especially interesting because of the social habits of many of its members. Many scientists have devoted their entire time to a study of just this order. The earlier observers of bees and ants assigned almost human intelligence to these insects. It is true that the organization of insect colonies, the division of labor, and behavior are remarkable, but recent studies tend to disprove earlier ideas. Major Hingston of the English army has studied and experimented with the social insects, especially wasps. Dr. Morton Wheeler is another contemporary student of this group. Teachers should consult the books by some of these authorities for proof of any statements they may find in popular books on insects. So many children's story books fictionize ants and bees that many misconceptions have arisen concerning them.

The behavior of bees and wasps is now believed to be instinctive and inherited. Following is an illustration that the author has observed.

This case was of a digger wasp. The female wasp was observed digging holes in the ground, in which to lay her eggs. She would dig a hole, fly away, return with a paralyzed katydid, lay the katydid down by the hole, disappear into the hole, reappear, pull the katydid into the hole. In a few minutes, she would reappear, plaster up the opening of the hole, and start digging another hole.

After watching this procedure for some time, the observer decided to fool the wasp. When the wasp had laid a katydid on the ground and disappeared into the hole, the katydid was picked up.

The wasp came up, looked distracted, ran around the hole a few times, and finding no katydid, returned to the hole. Apparently she laid her egg for she remained in the hole the same length of time as before. Then, reappearing, she plastered up the hole and proceeded to dig another hole. This was repeated several times with the same results. Had the wasp been a thinking animal, she would have caught another katydid when she discovered one gone. But the pattern of her instinctive behavior was fixed and apparently when one link in the chain was broken, she jumped to the next.

Honeybees have an elaborate social system which is so well known and written about that the teacher will have no trouble reading for her own information. *The National Geographic Book of Insects* or Mrs. Comstock's *Handbook of Nature Study,* revised edition, are good sources of information.

Science Concepts:

1. There are three kinds of bees in a hive: workers, queen, drones.
2. The workers are undeveloped females. They do all of the work of the hive.
3. The worker bees gather nectar and pollen from flowers. They use these for food and to make honey and wax.
4. In gathering pollen and nectar, bees help to cross-pollinate flowers.
5. Bees have special modifications of their bodies which help them to do their work.
6. Worker and queen bees have modified tips to their abdomens, with which they sting.
7. Drones have no stings, nor can they feed themselves. Their one purpose is to mate with the queen. Only one drone does this. The others die.
8. The queen bee is the mother of the hive. She lays the eggs and leads the swarm.
9. The queen is a female that has had special food and care. Her tongue is too short to reach into a flower to feed herself, so the workers feed her.

10. Bees store honey in storage cells of the hive. This food keeps the queen and workers alive through the winter. The drones are driven out of the hive in the fall, or simply allowed to starve. Like the queen, they are unable to feed themselves.
11. Bees are important to man not only because of the honey they store but because of the part they play in the interdependence in nature.

PROBLEM A. HOW DO BEES LIVE AND DO THEIR WORK? (Pages 304–325)

The teacher may introduce this problem in a number of ways, such as:

1. Bringing in a comb of honey and asking what the children know about it.
2. Showing a cake of beeswax and letting the children smell and feel it, tell what they know, or give ideas as to what it is and where it came from.
3. Having a demonstration hive of bees to observe. Directions for making one will be found in another part of the manual.
4. Going on a trip to some blossoming fruit trees or shrubs to observe insect visitors.

Suggested Activities:

1. Capturing pollen-laden bees in glass jars and observing at close range to find structures mentioned in the story. Observe the hind legs closely to see how the groove and long hairs collect the pollen. Release bees after studying them.
2. Capturing a worker that has been gathering nectar, and putting a hungry bee into the jar with it. Watching the hungry bee beg and get fed.
3. Mounting parts of a dead bee, such as sting, back leg with pollen baskets, wings, mouth parts, eye, on slides to be examined under the microscope. If no microscope is avail-

able, hand lenses will show a good deal. The wings show tiny hooks along the joining edges.

4. Examining empty comb to see the different-sized cells, how they are constructed and arranged. A piece of foundation comb may be obtained from a beekeeper.
5. Visiting an apiary and observing the handling of the bees.
6. Melting a piece of wax with a thermometer in it to determine the melting point. Question, "Why do the bees come out of the hive on a warm day and fan it more than usual?"
7. Comparing the different kinds of bees found in the garden, such as bumblebees, carpenter bees, and leaf-cutting bees. Children may bring in flies or moths that resemble bees strikingly. These make good problems.

To one group who did this, the teacher said, "We were all fooled yesterday with the insect Beth brought to class. I tried to put its wings under the microscope today to show you the hooks, and found my mistake. After you look at it and look at these pictures, perhaps you will know what our mistake was." She had pictures taken from the *National Geographic* of bees and flies that resemble bees. When the children examined the insect in question, they discovered that it had just two wings. Its legs were not like a bee's and it had no sting. It was a fly. Thus was provided a good problem-solving lesson.

Honeybees may be watched as they work on early blooming shrubs and trees without danger of children being stung, if the bees are not disturbed. Have the children stand quietly, making no quick movements. If a bee should light on anyone, it probably will fly away again if the person is calm and doesn't strike at it. If a bee should happen to become tangled in a child's hair, lift the hair and let the bee crawl out. This may be avoided by having the girls tie scarves over their hair. Of course there is an occasional bee sting which may be quickly alleviated by removing the sting and applying ammonia or soda to the wound.

The training in what to do in case of an emergency is valuable to children; also learning not to be unnecessarily afraid of animals which are not in themselves dangerous. Flies are far more dan-

gerous than bees because of their role as disease carriers. Yet most people are afraid of bees and not of flies. We should teach children to be reasonable; not to be unnecessarily bold. No one wishes to be stung, so one wouldn't catch a bee in a bare hand. But bees are interesting to watch and can be watched with little danger, if the observers are quiet.

Following a bee from one flower to another is an activity which will impress upon children the interdependence between flowers and bees. They will discover that honeybees go systematically from one flower to another of the same kind, while some of the wild bees visit flowers in a hit-and-miss fashion.

Different types of flowers may be observed also. Some flowers are easily entered by bees; others have interesting modifications which help insure pollination. Snapdragons and flowers of similar structure are two-lipped. The bee lights on the lower lip and pushes her head against the upper lip to open it. In so doing, she brushes against the stamens and covers her back with pollen. If she has pollen already on her body from another flower, some of it is brushed onto the pad of fuzz on the flower's lower lip. When she leaves, the flower snaps shut and throws pollen onto the flower's stigma. A search through a flower garden will reward a class with numerous devices possessed by flowers. Be careful not to put a nonscientific interpretation upon these structures. The plant species has survived because it *possessed* these modifications. The modifications didn't develop in response to a need.

If it isn't possible to visit an apiary, a demonstration hive is well worth the effort involved in construction. It can be made from one section of an ordinary hive with a row of filled supers. Build a tight frame around it extending far enough on each side to accommodate panes of glass and beaverboard covers. The glass is fastened against the hive but the covers are hinged so they may be opened like doors when the bees are being observed. A hole is bored through one end of the frame near its base to admit the bees, and a covered passageway is constructed to lead to the outdoor exit. It is placed on a support from a window sill at right angles to the window. A board fitted tightly into the window opening has a hole which fits the exit end of the passageway. The

hive should be stocked by a bee man. Observation hives may be bought from A. I. Root Co., Medina, Ohio.

Answers to Questions on Pages 324–325:

1. Cross-pollination; manufacturing honey and wax.
2. Honeybees live wherever there are flowers.
3. By having the hives in a protected place and having them well-built.
4. By cross-pollinating flowers of various crops upon which the farmer depends for seed and fruit.
5. Such plants as clover and fruit trees have flowers that provide good-tasting honey.

6–7. The color and flavor of honey is modified by the flowers from which the bees obtained the nectar.

8. Honey crystallizes in the refrigerator. It doesn't spoil at room temperatures, so there is no need for refrigeration.
9. No. Because honeybees do not eat leaves.
10. Beekeepers use smoke to quiet bees when they work with them.

XIV. BIRDS OF PREY (Pages 326–339)

This topic is also part of the big one on interdependence of living things. The children have studied the interdependence of plants and insects. They have studied about birds, such as woodpeckers, that prey upon insects. Here is a group of birds that prey upon some other animals, many of which are pests to man. Thus the predators are helpful to man. The predatory group is a much misunderstood one and maligned as a group because of the harm done by a few members.

As background for this material, the teacher needs to know something about the characteristics of birds and their habits.

Birds are warm-blooded vertebrates with a covering of feathers. In classification of animals, vertebrates are the highest. The lower vertebrates are cold-blooded. Only birds and mammals are warm-blooded. Cold-blooded means that the blood temperature does not remain constant, but changes with the surrounding temperature. Warm-blooded means having a constant temperature.

Classes of Vertebrates	*Common Animals in Class*	*Habitat and Breathing*	*Covering*	*Type of Reproduction*
Pisces	Fish	Water Breathing by gills	Scales Plates Smooth skin	Eggs laid in water. Fertilized in water
Amphibia	Mud puppies Salamanders Newts Frogs Toads	Water and land Breathing by gills, then lungs	Smooth skin	Jelly-covered eggs laid and fertilized in water Metamorphosis
Reptilia	Turtles Alligators Crocodiles Lizards Snakes	Typically land; lungs all their lives; some live in or around water	Scales or Plates	Eggs with leathery shells laid in sand or under stones and dirt; some born alive
Aves	Birds	Land and air; lungs and air sacs	Feathers	Eggs with brittle shells; incubated by mother in nest
Mammalia	Dogs and cats Cattle Horses Man, etc.	Land Lungs	Fur or Hair	With one exception are nourished in body of mother through embryonic stages and born alive

The one exception mentioned under reproduction of Mammalia is the Australian duck-billed platypus. Since the war, children are more familiar with animals from foreign countries. Australia is the home of several primitive animals. The platypus and spiny anteater are the most primitive of mammals. They lay eggs, similar to turtle eggs, which are kept warm by the mother. The young feed on milk.

The class *Aves* is subdivided into orders, and these orders are further subdivided into families. These families are commonly known as the thrush family, the finch family, and so on. For practical purposes in helping children answer questions about birds, we can make a nontechnical classification based on the way birds get food:

I. Water Birds (Those birds living near water and getting food from it.)

1. Divers: Loons and Grebes
2. Swimmers: Ducks and Geese
3. Flyers: Terns and Gulls
4. Waders: Herons, Bitterns, Sandpipers

II. Land Birds

1. Scratchers: Quail, Pheasants, Grouse, Turkeys
2. Predators: Hawks and Owls
3. Climbers: Woodpeckers
4. Perchers: All the song birds

Many of the land birds have been discussed in the earlier books of the series. Water birds are in the next book.

The water birds are more primitive in their structure and habits than land birds. Song birds are the most highly developed of all. Since song birds are also the most familiar of birds, we start teaching about them first, and move on to more unfamiliar ones as the children's experiences are widened.

The predators include several families of birds that are not so closely related in structure as they are in habits. Hawks and owls differ in the structure of their skulls, eyes, and feathers. But because they both prey upon other animals, chiefly rodents, we consider them together.

Most farmers dislike hawks and kill every one they can, irrespective of whether it is preying upon chickens or not. Many studies of the stomach contents of hawks have proved that most hawks are helpful.

Many bulletins and several good books have been published on hawks. The teacher should familiarize herself with the facts to be able to direct the unit. See the reference list.

Science Concepts:

1. Hawks and owls are called *birds of prey* because they eat other animals.
2. The beaks and feet of predators help them to get their food.

3. Hawks and owls swallow their food whole and regurgitate the bones and fur in pellets.
4. Owls are able to see at night better than other birds. They hunt mice and rats at night.
5. Most owls are helpful to man and should be protected.
6. Hawks hunt in the daytime and catch mice, rats, frogs, insects, and other animals.
7. Most hawks are helpful. Cooper's hawk and the sharp-shinned hawk are the ones that catch chickens. The other hawks should be protected.

Problem A. How Are Owls and Hawks Important to Man? (Pages 327–339)

Suggested Activities:

The problem may be introduced by a pellet as suggested in the story; or by a dead hawk that a farmer has shot; or by a live hawk that is seen on a field trip. If a dead hawk or owl is found, much will be learned if its crop is examined to find out what it has been eating. If the teacher is squeamish about doing this, some of the boys are usually glad to do it. She may say "It would be interesting to know whether this hawk was actually a chicken hawk or not. How could we find out? Would someone like to open the crop for us?" The crop may be slit with a pair of sharp scissors without opening any more of the bird, as there is no muscle between the crop and the skin. Forceps will help hold the skin back. Dissecting a bird is no more unpleasant than dressing any fowl.

In one group, a boy had a tame sparrow hawk which he had raised and taught to falcon. He brought it to school to show the children. It was a beautiful bird and stimulated the children to ask many questions.

Screech owls' or barn owls' nests are often made near homes, and the children hear the birds at night. In the daytime, they frequently see the birds sitting asleep near the trunk of a tree or in some other protected spot.

Hardly a spring passes that someone doesn't bring a young owl to school. They are interesting to study but hard to feed. If one is brought in it may be fed for a while on pieces of meat. You may

have to hold the bird's mouth open and poke the meat down into its throat. A pair of forceps is good for this purpose.

Sometimes older hawks or owls are injured and must be cared for until able to fly. They should be kept in a cage and their food put into the cage. If the meat is wrapped in cotton, the birds will often eat it when they wouldn't otherwise. Of course live mice will suit them best, but it isn't always possible to provide these. Keeping such a bird in captivity for a while is one of the best activities to teach children about these birds.

Children may make food charts of the common predators of their region. Government bulletins will give them data.

If a museum is available, the stuffed hawks and owls may be compared to help answer questions of size and color. Let the children solve the problem of how the birds are fitted to the life they live and food they get.

The experiment on page 334 is very amusing if you can get a live screech owl. It will help settle the misconception many people have that owls can't see in the daytime.

If a great horned owl should be brought in, be careful that the children don't get too near it. Horned owls have large beaks that are capable of making painful wounds. They don't attack human beings if left alone, but will snap at an outstretched hand.

The children may locate a sparrow hawk's nest as this bird often builds on ledges of buildings. Marsh hawks' nests are frequently found, also. They are worth observing.

A field trip to a grove where owls roost will often reward the class with the pellets that have been dropped on the ground under the trees. They are dry, gray, cocoon-shaped masses of fur and bones—not at all repulsive as one might expect. In one pellet, one may often find the clean white bones of two mice, sometimes of different kinds. The fur will be like powder. Children can better understand how scientists know about the food habits of these birds after such a study.

Answers to Questions on Page 339:

1. Red-tailed hawks are very helpful. A food chart would prove this.

2. This was a marsh hawk, one of the helpful ones. It is the only grayish hawk with a white rump.
3. Because owls hunt at night, their habits have not been so well known as those of other birds. Many superstitions and misconceptions have grown up around the owl because of the mystery of things happening in the dark. Ignorance leads to nonscientific attitudes.
4. You can find the answer to the question by writing to your State Department of Conservation.

XV. LIFE AMONG THE ANTS (Pages 340–357)

This topic very naturally follows the one on bees. While on field trips, the children may notice ants going up and down the stems of plants. They may ask if the ants are eating the plants. Ants often discover aphids on plants and capture them for the honeydew secreted by these "ants' cows." This is another insect plant interrelationship very interesting to children. If an aphid is examined through a lens, one can easily see three tiny tubes protruding from its abdomen.

Ants belong to the same order of insects as do bees and wasps. This order is Hymenoptera. This order has the most highly developed organization among the insects.

Ants are similar to bees in having castes and in living in colonies. There are many different kinds of ants, some living in the ground, some in wood, and some in other interesting environments.

The stories in pages 340–357 are about a few of the ones more interesting to children. If other kinds of ants are common in your region, Wheeler's book on ants will help answer questions that may come up.

Since male ants swarm after the queen at mating time, just as bees do, the incident introducing the chapter sometimes occurs. Most of the swarm are drones that die very soon, but while they are invading the house they are a nuisance. They cluster around a queen and may be killed with any insect spray or powder.

The termites that are a pest in some parts of the United States are not ants, though they resemble them superficially.

Science Concepts:

1. Ants are like bees in having queens, workers, and drones.
2. Most ants live in the ground instead of in hives.
3. Ants, bees, and wasps are called social insects because they live and work together.
4. In the spring, young queen and drone ants grow wings with which they take their nuptial flight.
5. After mating, the queens start new hills.
6. Queen ants lay the eggs which hatch into small white larvae.
7. The life history of an ant consists of egg, larva, pupa, and adult.
8. The worker ants make the ant hill, care for the queen, protect the hill, and care for the young ants.
9. Some ants use aphids as cows.
10. Some ants store honey. They are called honey ants.
11. The habits of ants are very interesting. There are many kinds of ants.
12. Ants are not helpful to man the way bees are. Some of them are harmful.

PROBLEM A. HOW ARE ANTS IMPORTANT TO MAN? (Pages 340–357)

The best activity in studying ants is to make an observation nest as suggested on page 357. If the children should find aphids on a plant with ants going up and down the stem, let them watch the ants milk their cows. Put a few ants in a dish with the aphids and watch them through a hand lens.

Be careful not to let children get the misconception that ants think. The habits of social insects are so much like those of people that it is easy to assign human reasons to their behavior. It is of course instinctive. Ants today do the same things that their ancestors did thousands of years ago.

Ways of getting rid of ants should be discussed. In some places they are a pest, getting into houses and finding the food, or making hills in lawns. Several commercial ant powders are very effective.

XVI. MACHINES (Pages 358–372)

Problem A. How Do Machines Make Work Easier? (Pages 358–372)

This problem may be introduced in many ways. A heavy object to be moved is an excellent problem. "How can we move this object?" Any kind of construction going on in the community will afford many examples of pulleys, wheels, and levers. The children's toys, bicycles, and wagons have many examples of these simple and complex machines.

The concepts to be developed are given so clearly as to make a listing unnecessary.

Suggested Activities:

Use a board for a lever, a block of wood for a fulcrum, and a boy or girl for the weight. See how far from the fulcrum the force has to be to lift the child. The main idea for the children to get is that they can lift with a lever weights that otherwise they are unable to lift.

Suggest that the children make a list of all the levers they can find at home.

Let the children do the experiment on pages 364–365. The rule is: the weight times the distance from the weight to the fulcrum equals the force times the distance of the force from the fulcrum.

The answers to the problems at the bottom of page 365 are:

1. The 120-pound boy would be 3 feet from the fulcrum and the 40-pound boy 9 feet from it. $120 \times 3 = 40 \times 9$.
2. 20 pounds.

To demonstrate a wedge, try to open a wooden box that is tightly nailed, with the fingers. Then pound a chisel between the lid and box. An axe edge, a screwdriver, and many other common tools are wedges. They are actually double-inclined planes. A nail works in the same way.

Inclined planes may be demonstrated by lifting a weight straight up with a spring scales and noting the amount of pull on the scales. Then pull the same weight up a smooth, inclined board and note the pull on the scales. Vary the angle of the plane.

The value of a wheel is easily demonstrated by using a scales to pull a box full of rocks on the floor. Then put rollers or wheels under it and pull again. Spools may be used, or cardboard mailing tubes.

Putting the wheels on axles will make it still easier. Children could integrate this with study of transportation in social studies. An interesting exhibit of the development of the use of wheels could be made.

A bulletin board with a wheel as a center could radiate out to the machines using wheels.

A screw is really a spiral inclined plane that sacrifices speed for gain in force, just as a winding mountain highway does. A meat grinder is a common machine using a screw.

Derricks of all kinds use pulleys. Windows go up and down by pulleys. A little investigation will reveal many pulleys around home and school.

In the experiments on page 371, the force won't be exactly the same as the weight because of friction. The less the friction, the more exact it will be.

Teachers should read about these simple machines, if their own background is lacking, and try to provide simple ways for children to experiment. Many teachers have the mistaken idea that girls are not interested in machines. If they are given an opportunity to experiment with the common machines within their experiences, there is no difference between the interest of boys and girls.

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A KEY TO THE COMPANION BOOK

p. 1—*Your Garden*

The flowers named in column 1 will be colored.

p. 2—*Flower Families*

Check: 1, 2, 4, 5, 6, 7.
Underline: 2, 4, 5, 6, 7.

p. 3—*Seeds of Weeds*

Individual answers.

p. 4—*Why Should We Get Rid of Weeds?*

1. *a.* harmful   *b.* expense   *c.* poisonous
2. Check: Column 1: *a, d*
   Column 2: *b, e*
   Column 3: *c*

Where Weeds Are Found

1–3. Individual answers.

p. 5—*Don't Jump to Conclusions*

1. Check: *a, b, c, d.*
2. Check none of these sentences.

p. 6—*Don't Jump to Conclusions* (continued)

3. *a.* ideas; jumped to a conclusion (or was hasty in making a statement)
   b. liked; jumped to a conclusion (or made a statement that had no proof)
   c. thought; was hasty in making a statement (or jumped to a conclusion)
   d. seeds; jumped to a conclusion (or was hasty in making a statement)
4. *a.* many   *b.* not   *c.* said   *d.* facts
5. *b, a, c, d*
6. Check *e* in 2.

p. 7—*Ferns*

1. Marginal shield
2. Sensitive
3. Ostrich
4. Christmas

p. 8—*Parts of Plants*

Check: A fern—roots, stems, leaves
A weed—roots, stems, leaves, flowers, seeds
A moss—stems, leaves
A mushroom—stems

p. 9—*The Fairy Rings*

Underline: The fairies grow the mushrooms in circles so that they will have a place to meet. At night, just at twilight, the fairies gather at the fairy rings. Each fairy sits on top of a mushroom. They hold a meeting. They talk about the boys and the girls in the neighborhood. If the boys and girls have been good, the fairies visit them and do nice things for them. If they are bad, the fairies stay away. . . . so that the fairies will not be frightened and do nice things for me.

1. Check: *a*, *b*, *c*, *e*.

Underline: You see, the mycelium can produce mushrooms year after year. As the mycelium uses up the food in one place, it grows out and away from that place. But as it grows, it sends up other mushrooms in a wider circle. Each year the circle gets larger. Many, many years ago people with good imaginations called these circles of mushrooms fairy rings.

p. 10—*Mold*

1–3 (except 3 *c*.). Individual answers.
3 *c*. drying
3 *d*. Some examples are beans, peas, prunes.

p. 11—*Why Are Some Foods Light?*

1. Cross out in each list: flour, salt, shortening.
2. Check: baking powder, milk in the lists of ingredients of spice cake, muffins, and biscuits.
3. baking powder

4. Underline: When the dough is heated in the oven, the baking powder causes carbon dioxide to form. The bubbles of carbon dioxide make the dough rise.
5. baking powder; yeast

p. 12—*Preventing Athletic's Foot*

1. Picture 1: check floor under showers and the floor in the rest of the building.
   Picture 2: check beach.
   Picture 3: check inside of tub and on floor.
   Picture 4: check diving board and walk around pool.
   Picture 5: no check marks.
   Picture 6: check walk around pool.
2. water; the fungi need moisture for growth.
3. Check: *a*, *b*, *c*, *e*.

p. 13—*Controlling Tuberculosis and Typhoid Fever*

1. increased
2. decreased
3. Check all the sentences.

p. 14—*Reading to Find Information*

1. Put one line under: Some bacteria are harmful. They cause many diseases of both animals and plants. Typhoid fever and tuberculosis are diseases caused by bacteria.

   Put two lines under: Not all bacteria are harmful. Some are useful to both plants and animals.

   Certain useful bacteria grow on dead plants and animals. They cause the plants and animals to decay.

   They are useful to these plants in the following way.

   Some bacteria in the soil can take nitrogen from the air. They can change nitrogen into a form that the green plants can use. These bacteria are very necessary.
2. *a.* two *b.* one

p. 15—*Science Is International*

1. none 2. 8 3. birds 4. birds

p. 16—*Theories of Bird Migration*

Check: 1, 3, 12.

p. 17—*Why Do We Have Theories?*

1. B 2. B 3. A 4. C 5. C 6. C

What Do We Know About Birds?

Put a T before 2, 4, 5, 6.

p. 18—*Famous Journeys*

1. 6, 7, 8, 9
2. 1, 2, 3, 4, 5
3. They all begin at a definite place and end at a definite place.
4. The bird routes go mostly north and south; the routes of men go mostly west and east.

p. 19—*Airways and Flyways*

1. They are definite routes.
2. Some airplane routes go east and west to connect cities. The bird routes go north and south. They do not connect cities. (To the Teacher: Any answer expressing these ideas is all right.)
3. The flyways don't go where airplanes need to go.
4. Birds have different destinations. They go north or south.

p. 20—*The Speed of Birds*

Chart: duck hawks:	164–180 miles in a diving flight
horned larks:	22– 28 miles
robins:	23 miles

Graph: The names of the birds will be arranged as follows: duck hawks, swifts, ducks, geese, robins, herons, horned larks, flycatchers.

p. 21—*Birds and Clouds*

1. cirrus
2. nimbus, stratus
3. cumulus nimbus, stratus
4. no
5. no
6. go over the mountains

p. 22—*Wings and Flight*

1. Position on body of bird; feathers and feather arrangement; general structure, such as skeleton; method of motion.
2. Length; shape (some are pointed, some rounded, etc.); size of wings in proportion to size of the body.

p. 23—*The Life Cycle of the Salmon*

1st Column:

3. (Done)
8. Dead salmon.
6. Salmon laying eggs in a stream.
5. Salmon swimming up the rapids.

2nd Column:

2. Salmon drifting downstream.
4. Salmon entering the mouth of a river.
1. Young salmon swimming in a mountain stream.
7. Salmon fertilizing eggs.

p. 24—*Animals on the Move*

1. salmon, p. 56
2. eel, p. 58
3. Arctic tern, p. 43
4. Monarch butterfly, p. 59

p. 25—*People Move*

1. no
2. no
3. no
4. yes
5. no
6. northeastern United States
7. western United States

p. 26—*The Struggle for a Living*

1. lightning plant	2. fog lower animals	3. support plant
4. water lower animal	5. food lower animal	6. food man
7. oxygen man	8. water plant	9. food lower animal

p. 27—*Plants and Animals During Winter*

A. Column 1—Plants: check 1; circle 2, 3, 4, 5.
Column 2—Amphibians: check 3, 4, 5, 7; circle 1, 2, 6.

B. Put a T before 1, 4, 5.

p. 28—*Hibernation*

1. does not hibernate
backbone
2. hibernate
backbone
3. hibernate
backbone
4. hibernate
backbone
5. does not hibernate; backbone
6. hibernate
backbone
7. hibernate
no backbone
8. hibernate
no backbone
9. hibernate
no backbone

Draw X's on 2, 3, 4, 7, 8, 9.

p. 29—*Seeing, Hearing, and Smelling Danger*

1. hear, see
2. see
3. see
4. hear
5. see, hear
6. see, feel
7. hear, see, smell
8. see, feel
9. see
10. see

Blank at the bottom of page: no

p. 30—*Animals I Know*

Individual answers.

p. 31—*What Would I Be Like If ______________?*

Some examples are:

1. my size, trunk, and tusks
2. hiding
3. swinging to other trees
4. closing my shell
5. my color or running away
6. gliding away or hiding
7. hiding in a hole
8. hiding under a rock
9. teeth, claws, and hiding
10. running away, my hoofs, my color, or my sense of smell
11. my scent
12. my tusks and going under water

p. 32—*How Did Man Protect Himself Before He Used Plants and Animals As He Does Now?*

1. cave	4. the man's skin	7. spear
2. club	5. the man's eyes	8. stones
3. fire	6. the man's ears	

p. 33—*Can You Pick Them Out?*

1. hawk, seal	4. bear, frog	7. cat, squirrel
2. deer, hawk	5. tiger, bear, dog	8. dog, rabbit, deer
3. all of the animals	6. deer, dog	

p. 34—*Can You Pick Them Out?* (continued)

9. beaver, seal, frog
10. cat, tiger, bear, dog, squirrel, rabbit

How Are These Animals Protected?

Some examples are:

leopard: color, teeth, claws, eyes
crayfish: shell, eyes, diving, lose pincers and they will grow again
elephant: tusk, trunk, size, color
deer: smell, color, eyes
horned toad: color, horned scales, swift movement
porcupine: quills, color, ability to climb into trees
snake: swift movement, shape, color, lies as though dead
skunk: color, odor
electric eel: produces an electric current, swift movement
turtle: shell, color, diving into water
walking stick: looks like a stick (or shape and color), shell-like covering
toad: secretion from skin, color
quail: color, flight

p. 35—*How to Make a Conclusion*

1. Underline:

A. birds	G. mammals
B. fish	H. animals
C. insects	I. animals
D. mammals	J. animals
E. amphibians	K. animals
F. reptiles	

2. *a.* 7
   b. birds, fish, insects, mammals, amphibians, reptiles, animals

p. 36—*How to Make a Conclusion* (continued)

2. *c.* animal
   d. animal

3. Underline in red on page 35:

   A. migrate
   B. migrate
   C. migrate
   D. migrate
   E. hibernate
   F. hibernate
   G. hibernate
   H. shape
   I. color
   J. see, hear, smell
   K. weapons

   a. 8
   b. migrate; hibernate; shape; color; see, hear, smell; weapons
   c. survive
   d. Animals survive.

4.

Animals	*Survive*
birds	migrate
fish	hibernate
insects	shape
amphibians	color
reptiles	see, hear, smell
mammals	weapons

5. *a.* animals *b.* surviving *c.* yes

p. 37—*How to Make a Conclusion* (continued)

5. *d.* Animals are able to survive because they are protected.
6. 1, 2, 4, 6, 3, 5, 7, 8

Test Yourself

Migrate: birds, insects, fish, mammals
Hibernate: insects, reptiles, fish, mammals, amphibians

p. 38—*Metamorphosis*

A. Check: 1, 2, 5. B. Check: 1, 3, 4.

p. 39—*Insect Pests*

1. scale insect
2. grasshopper
3. corn borer
4. Japanese beetle
5. boll weevil

Draw lines:

from scale insect to woodpecker, poison spray, song bird
from grasshopper to bran mash poison, farmer plowing, crow
from corn borer to quarantine inspection sign or inspector
from Japanese beetle to woodpecker, poison spray, crow
from boll weevil to quarantine inspection sign or inspector

p. 40—*Breeding Places of Flies and Mosquitoes*

Put X's on garbage can, pail under pump, manure pile, barrel, can, swamp, unscreened window.

Individual drawings.

p. 41—*How Two Scientists Worked*

1. observed
2. thought of a theory
3. experimented
4. examined their results
5. conclusions
6. *a.* used mosquitoes and people in his experiments
   b. used cows and people in his experiments
7. method, materials used

p. 42—*Plants and Animals Reproduce*

A. 1. living 2. old 3. living

B. 1. spore cases

p. 43—*Plants and Animals Reproduce* (continued)

B. 2. eggs
3. soil
4. water
5. cotton boll
6. eggs, fertilizes
7. fertilized
8. different

How Plants and Animals Depend on Each Other

Put a B before 1, 5, 9.

Put an F before 4, 5, 6, 7, 8, 9, 10, 11, 12.

p. 44—*Flower Parts*

1. petal, stamen, pistil
2. petal, stamen, pistil, sepal
3. petal, pistil, stamen
4. sepal, stamen, pistil, petal
5. petal, sepal, stamen, pistil
6. petal, pistil, stamen, sepal
7. sepal, pistil, stamen, petal
8. petal, pistil, stamen, sepal
9. petal, stamen, pistil, sepal
10. petal, stamen, pistil
11. stamen, pistil, petal, sepal
12. petal, pistil, stamen

p. 45—*Can You Pick Them Out?*

1. Any five: house fly, boll weevil, mosquito, silkworm, Monarch butterfly, honeybee, corn borer, ladybird beetle, Japanese beetle
2. Any two: dragon fly, grasshopper, praying mantis
3. dragon fly, ladybird beetle, praying mantis
4. house fly, mosquito
5. silkworm, honeybee
6. corn borer, Japanese beetle
7. Japanese beetle, boll weevil, grasshopper, corn borer
8. honeybee
9. Monarch butterfly
10. mosquito

p. 46—*A Review*

1. protection	5. reproduction	9. migration
2. migration	6. hibernation	10. protection
3. reproduction	7. reproduction	11. migration
4. hibernation	8. reproduction	12. migration

p. 47—*How Is Sound Made?*

1. blow it	4. prick it	7. blow it
2. turn it on	5. turn it on	8. strike it
3. make it turn	6. wave it rapidly	9. pour the liquid into the glass

Blanks: air, motion

p. 48—*Records of Some Experiments with Sound*

EXPERIMENT 1

I. Check: 4.

II. 1. hand 2. upward

III. 1. vibrated 2. vibrated 3. sound

IV. vibrated, vibrate, sound

p. 49—*Records of Some Experiments with Sound* (continued)

EXPERIMENT 2—DIRECTION 2

I. Check: 4.

II. wood

III. 1. vibrated 2. vibrated 3. sound

IV. vibrated, vibrate, sound

p. 50—*Records of Some Experiments with Sound* (continued)

EXPERIMENT 2—DIRECTION 3

I. Check: 3

II. 1. wood 2. water

III. 1. direction 2. stopped 3. could not

IV. go in every direction, tuning fork

p. 51—*Records of Some Experiments with Sound* (continued)

EXPERIMENT 2—DIRECTION 4

I. Check: 4.

II. 1. fork 2. cheek 3. vibrations 4. hum

III. 1. vibrations 2. hum 3. stopped

IV. vibrating, sound

p. 52—*Doing Experiments*

I. Individual answers.

III. 1. Hold one end of a knitting needle on the edge of the table. Pull the needle upward and let it go quickly.

2. Hold your hand near the vibrating needle; or strike a tuning fork and hold it close to your cheek.

3. Strike a tuning fork. Hold it close to your cheek until the sound and vibration stop.

p. 53—*The Direction of Sound Waves*

Pictures 1, 2, 3: Arrows showing sound waves going in all directions.

Picture 4: Arrows showing sound waves going out of the end of the bell that the child is holding upward.

Picture 5: Arrows showing sound waves going out of the body of the horn.

p. 54—*What Causes An Echo?*

Picture 1: *echo* near the cliff

Under pictures 2 and 3: nothing to reflect sound

Picture 4: echo on walls and ceiling

Blank lines: Sound waves are reflected back to the ears from the cliffs and walls.

p. 55—*A Puzzle with Ears*

Obvious.

p. 56—*How Do You Hear?*

1, 10, 7, 2, 5, 4, 6, 8, 3, 9

p. 57—*Why Does Mercury Go Up in a Thermometer?*

Check: 2, 3, 4, 5, 6, 7.

2. Circle: walls were.	Write: mercury was.
3. Circle: paper.	Write: mercury.
4. Circle: paper.	Write: mercury.
5. Circle: walls.	Write: glass tube.
6. Circle: paper loosened.	Write: mercury went up in the tube.

p. 58—*Why Does Mercury Go Up in a Thermometer?* (continued)

Check: 9, 10.

10. Circle: paper; walls. Write: mercury; glass tube.

Blank lines: The mercury expands more than the glass tube so the mercury goes up in the tube.

Why Does Mercury Go Down in a Thermometer?

Check: 1, 2, 3.

1 Circle: ice; wire grow shorter. Write: cold alcohol; mercury go down.

3. Circle: ice; wire. Write: cold alcohol; mercury.
4. The mercury goes down because the cold causes the mercury to contract faster than the glass tube.

p. 59—*How a Large Problem Is Analyzed*

A. *a.* 1, 2, 3 *b.* 1 *c.* 2 *d.* 3

B. 1. *e*	4. *e*	7. *d*
2. *e*	5. *c*	8. *d*
3. *a*	6. *d*	9. *d*

C. Heat causes gases, liquids, and solids to expand, and cold causes them to contract.

p. 60—*Air Presses on Many Things*

Under all the pictures, write *Air Presses.*

Arrows showing that air is pressing on everything in the pictures.

p. 61—*How Does Air Pressure Affect Me?*

1. air
2. 373
3. pressure
4. 164–174; 176–177; 180; 183–187
5. Sentences taken from:
   the last paragraph on p. 164;
   the last four sentences on p. 164;
   all of p. 166;
   all of p. 169;
   the first paragraph on p. 170;
   the second paragraph on p. 180;
   the second paragraph on p. 183.

p. 62—*The Parts of a Plane*

Answers may be found on p. 66 of the Companion Book.

p. 63—*The Uses of the Parts of a Plane*

1. straight ahead 2. to the right 3. to the left

p. 64—*The Uses of the Parts of a Plane* (continued)

2. 1. straight ahead 2. up 3. down
3. *a.* right
   b. to the right
   c. Obvious.
   d. Gravity pulls down more on the left wing and tips the plane a little.

p. 65—*Birds and Planes*

Obvious.

p. 66—*Birds and Planes* (continued)

1. rising 2. soaring 3. turning 4. descending

p. 67—*The Weather Where I Live*

Individual answers.

p. 68—*A Record of the Weather in my Community*

Individual answers.

p. 69—*Wind*

Number: map 3; mountain scene 2; beach scene 1.

Words: map—changing air pressure
mountain scene—unequal cooling, unequal heating, air
beach scene—sun's heat, land, water

p. 70—*Barometers and Thermometers*

A. Put a B before 1, 2, 4, 7; put a T before 3, 5, 6, 8.
B. 1. air pressure 2. temperature
C. 1st barometer: 3, 5 1st thermometer: 4
2nd barometer: 1, 6 2nd thermometer: 2

p. 71—*Use of the Index, A Review*

1. *a.* 181; cooler, heavier air causes warmer, lighter air to move up and makes a draft
   b. 154; when substances become larger
   c. 157; when a substance gets smaller
   d. 189; vapor cooling enough to form drops

2. *a.* 64–65; being kept from harm
   b. 56; movements of animals from one place to another for feeding or breeding
   c. 66; spending the winter in a dormant state
   d. 109; production of young
3. not alive; alike

p. 72—*Where Do Fuels Come From?*

1. Pennsylvania, West Virginia, Ohio, Illinois, Iowa, Kansas
2. California, Texas, Oklahoma, Kansas, Colorado, Montana, Louisiana
3. same as 2

p. 73—*Where Is Carbon Found?*

Individual answers.

p. 74—*Fire and Oxygen*

Put O's around fire.

1. Use a fire extinguisher; let it burn out.
2. Use a fire extinguisher; let it burn out.
3. Pour water on it.
4. Use a fire extinguisher or put dirt on it.
5. Call a forest ranger and make a fire line.
6. Make a fire line; put dirt or water on it.
7. Turn it off.
8. Blow it out.

p. 75—*Some Organs of the Human Body*

Boy: small intestine, stomach, esophagus, mouth
Girl: mouth, esophagus, stomach, small intestine

p. 76—*Health Habits*

Individual answers.

p. 77—*A Menu*

Consomme	protein
Leek and potato soup	carbohydrate
Grilled hake, butter sauce	protein, fat
spaghetti	carbohydrate
corn brisket	protein, carbohydrate

Buttered green peas	protein, fat, vitamins
Yellow squash, cream sauce	carbohydrates, bulky food, vitamins
Baked jacket and French fried potatoes	carbohydrates
Beetroot and onion salad	bulky food, vitamins
Chicory	bulky food, vitamins
Sago pudding	carbohydrate
Ice cream and wafers	carbohydrate, protein
Cheese	protein, vitamins
Fresh rolls	carbohydrate
Butter	vitamins, fat

Circle the items: Individual answers.

p. 78—*How Long Do People Live?*

A. 1. women, men
   2. women, men
   3. increased

B. Some examples are:
   1. Eat well-balanced meals.
   2. Drink plenty of water.
   3. Get plenty of sleep and rest.
   4. Follow regular habits of elimination.
   5. Do not eat too much.
   6. Eat fruits and bulky foods.
   7. Eat foods containing carbohydrates and proteins.
   8. Eat protective foods (vitamins).

p. 79—*Plant or Factory?*

1. F	5. P	9. P	13. F
2. F	6. F	10. F	14. F
3. P	7. F	11. P	15. P
4. F	8. P	12. P	16. F

p. 80—*What Are the Steps in Sugar Making?*

THINGS THAT HAPPEN IN THE SUGAR BEET
WHEN IT IS GROWING

1. Air goes into the leaf through openings on its underside.

2. The root hairs absorb water from the soil.
3. The root hairs absorb minerals that are dissolved in the water.
4. The water rises through the stem to the leaves.
5. The water and carbon dioxide are combined by chlorophyll.
6. Sugar and starch are made when carbon dioxide and water are combined in the leaves.
7. Some sugar is used by the plant and some is stored in its root.

THINGS THAT HAPPEN IN A SUGAR-BEET FACTORY

1. A large load of white beets is dumped into a stream of water.
2. The beets are emptied into a huge tank.
3. The washed beets are carried to the top floor on an elevator.
4. The machine slices the beets into shreds.
5. The shredded beets are dumped into a huge vat.
6. The shredded beets are cooked in the vat until most of the moisture is boiled out.
7. A machine filled with molasses turns rapidly.
8. The syrup turns into white sugar crystals.
9. The white sugar is put into sacks.

p. 81—*Where Is Sugar Grown?*

1. Colorado, Utah, Michigan, California, Idaho, Montana, Nebraska, Wyoming, Ohio
2. Individual answers.
3. Louisiana, Texas, Mississippi, Alabama, Georgia, Florida, South Carolina
4. Individual answers.

p. 82—*The Work of Plants*

Roots : Cross out 2, 3, 4.
Branches: Cross out 1, 4.
Flowers : Cross out 1, 2, 3, 4.
Stem : Cross out 1.
Leaves: Cross out 1, 2, 4.
Seeds : Cross out 1, 2, 3.

p. 83—*Just for Fun*

Individual answers.

p. 85—*Doing Experiments Safely*

1. He is using pliers (or forceps) to hold the pipe.
2. He should hold it with forceps or pliers.
3. electric; a metal tray or a piece of metal or glass; blow it out and put it on a tray.
4. Alcohol burns easily and it might catch fire if heated over a flame; she is holding the tube with forceps and is pointing the tube away from her; poison
5. There is no metal tray or piece of glass or metal under the stove.
6. Hold jar by the bottom. Hold splinter slanted.

p. 86—*Check the Safety Rules*

Check: 1, 2, 3, 4.

Write Some Safety Rules

Rules 1, 2, 3, 5, 6, 7, 8 from the exercise "Check the Safety Rules" in the upper half of page 86 of the Companion Book.

p. 87—*Plants and Animals Live Together*

1. AP	5. AP	9. PA
2. AP	6. AP	10. AP
3. AP	7. AA	11. AA
4. AP	8. AP	12. AA

p. 88—*Days and Nights Are Different Lengths*

Individual charts.

1. June
2. December
3. Days gradually grow longer and nights shorter as summer approaches. (Or any other answer that is correct.)

p. 89—*Revolution and Rotation*

1. rotation
2. rotation
3. rotation
4. rotation
5. rotation and revolution

Put an O on the girl in picture 5.

Put X's on: 1. merry-go-round; 2. top; 3. children; 4. hands of clock; 5. girl.

p. 90—*Birthdays and Seasons*

Individual answers.

p. 91—*A Graph About Birthdays and Seasons*

Individual graphs.

1. Individual answer.
2. Individual answer.
3. Spring: March 21–June 21
   Summer: June 21–September 23
   Autumn: September 23–December 21
   Winter: December 21–March 21

p. 92—*How Our Bones Are Made*

1. 1　　　2. 1

p. 93—*How Our Bones Are Made* (continued)

3. 1.2 grams
4. Individual answers.
5. 13–15
6. no
7. 1–12
8. more
9. They are growing faster. Bones are developing more during the ages of 13–15 than during the ages of 16–20.
10. Table A—Column IV: 4; 4; 4; 4–5; 4–5; 4; 5; 5
11. Table B—

One cup :	½ pint	¼ quart
Two cups :	1 pint	½ quart
Three cups:	1½ pints	¾ quart
Four cups :	2 pints	1 quart
Five cups :	2½ pints	1¼ quarts
Six cups :	3 pints	1½ quarts

p. 94—*The Skeleton of the Human Body*

See pp. 223, 225, 273 of How and Why Experiments.

p. 95—*The Skeleton of a Bird and the Skeleton of a Man*

Obvious.

p. 96—*Ligaments and Joints*

Obvious.

p. 97—*Disease and Life*

1. Individual answers.
2. Circle: measles.
3. Check: anthrax.
4. Individual answers.
5. Tuberculosis clinics for early detection of disease; X-ray units that give free chest X-rays; removal of children and babies from contact with tuberculars; care of patients in special sanitariums; education on how to prevent and care for tuberculosis; sale of seals. (Or any other answers that are correct.)

p. 98—*Patients and Health*

1935—8 stick men; 1939—10; 1943—15

p. 99—*Hospitals and Health*

Individual pictograms.

1. The number of patients increased in the period 1935–1939 while the number of hospitals decreased. (Or any other answer that is correct.)
2. hospitals, patients

p. 100—*Doctors and Health*

Pictogram: individual answers.

Blank lines at the bottom of the page: How to provide enough hospitals for people who need hospital care; how to provide enough doctors for people who need their services; (or any other problem answering the question).

p. 101—*Conservation of National Resources*

How Started:

1. building fire too near trees
2. leaving a smoldering fire
3. throwing matches into brush

How Prevented:

1. building a fire in a cleared space
2. covering a fire with dirt or water to put it out
3. placing burned matches in a metal container

p. 102—*Animals Which Fight Most Fiercely*

1. head: 15 check marks
   feet: 8 check marks
   muscles: 1 check mark
   tail : 1 check mark
2. head
3. Circle: killer whale, white shark.
4. Underline: crocodile, python.
5. Draw lines through: killer whale, white shark, elephant, hippopotamus, rhinoceros, African lion, tiger, jaguar, gorilla, orang-utang, python, leopard, hyena.

p. 103—*Extinct North American Animals*

Individual answers.

p. 104—*Poisonous Snakes*

Map: obvious.
Blank lines at bottom of the page: individual answers.

p. 105—*Problems About Bees*

A. 1. flower
2. stamens
3. pollen
4. flower
5. hairs
6. pollen baskets (grooves)
7. pollen

B. 1. tongue
2. lap up
3. honey stomach

C. 1. a bee (done)
2. on the bee's body
3. small grooves

p. 106—*Problems About Bees* (continued)

4. pollen baskets full of pollen
5. other worker bees
6. pollen
7. bees, workers
8. workers, when they gather their own food
9. workers
10. nectar
11. nectar
12. nectar
13. the worker's tongue
14. the bee
15. a bee
16. a bee
17. a bee
18. worker bees
19. worker bees
20. nectar
21. stomach
22. honey stomach
23. worker bees
24. worker bees, nectar

p. 107—*Honeybees*

A. 1. gather pollen
2. gather bee glue
3. gather nectar
4. make honey
5. make wax
6. build honeycombs
7. care for young bees
8. feed and care for the queen
9. ventilate the hive
10. clean the hive

B. 1. About 11, 11, 11, 18
2. #2
3. #1
4. #1

p. 108—*Honeybees* (continued)

C. 1. swarming
2. making queen cells
3. gathering nectar
4. guarding the hive
5. ventilating the hive

D. 1. Squirrel gathering nuts. (done)
2–10. Individual answers. Examples include: bird making nests; birds flocking in migration; cats stalking birds; dog turning around before lying down; sheep following a leader; wasps paralyzing spiders and putting them into cells; and so forth.

p. 109—*What Do Different Kinds of Bees Do?*

The Workers (9–13): Individual answers. Examples include: gather nectar; make wax; build comb; clean hive; keep hive at an even temperature; repair hive; make honey; make bee bread; and so forth.

The Queens: lay eggs; eat honey

The Drones: one mates with the queen; eat honey

Blanks: A. work B. bees C. work

p. 110—*A Beekeeper Could Answer These Questions About Bees. Can You?*

1. carry pollen from flower to flower (cross-pollination); make honey; make wax
2. wherever there are flowers
3. put the hives in a protected place; have the hives built well; see that the bees have enough food
4. cross-pollinate flowers of fruit trees and crops like alfalfa and clover

5. clover, orange trees in the southern states, apple and other fruit trees
6. The nectar from different kinds of flowers is colored differently.
7. Honey flavor is affected by the kind of nectar used.
8. It crystallizes in the refrigerator.
9. not if it is a stomach poison like Paris green. DDT might.
10. to quiet them—make them sluggish and easily handled.

p. 111—*Other Helpful Insects*

A. 1. Circle: ichneumon fly; grubs.
   2. The tiny grubs are hatched inside the tomato "worm" and eat the tomato "worm" which feeds on tomato leaves.

B. 1. Circle: wasp.
   2. The wasp catches a grasshopper and puts it into the hole for the young wasps to eat when they hatch. Thus, it helps destroy grasshoppers.

p. 112—*Helpful and Harmful Birds of Prey*

1. Harmful because the larger part of its food is small birds, poultry, and game birds which are helpful to man.
2. Harmful because the larger part of its food is small birds, poultry, and game birds which are helpful to man.

p. 113—*Helpful and Harmful Birds of Prey* (continued)

3. Helpful because the larger part of its food is mice and small mammals which eat the farmers' crops.
4. Helpful because the larger part of its food is mice and insects which would eat the farmers' crops.
5. Helpful because the larger part of its food is insects and mice which would eat the farmers' crops.
6. Helpful because the larger part of its food is insects, mice, and small mammals which would eat the farmers' crops.
7. Helpful because the larger part of its food is house mice, field mice, rats, and small mammals which would eat the farmers' crops.

8. Helpful because the larger part of its food is mice which would eat the farmers' crops.
9. Helpful because the larger part of its food is mice which would eat the farmers' crops.
10. Helpful because the larger part of its food is small mammals which would eat the farmers' crops.

p. 114—*Helpful and Harmful Birds of Prey* (continued)

11. Helpful because the larger part of its food is insects which would destroy the farmers' crops.
12. Helpful because the larger part of its food is mice, small mammals, insects, and spiders which would destroy the farmers' crops.

1. This was a red-tailed hawk—one of the helpful hawks. This hawk was soaring. Chicken hawks do not soar but sit on a hidden perch ready to swoop down on a chicken.
2. This was a marsh hawk—one of the helpful ones. It eats mice, frogs, and other small animals.
3. Since owls hunt at night and have a mournful cry, people are often startled by one. Sometimes an owl swoops down to catch a mouse and accidentally comes near a person. The owl's flight is so silent that the person is frightened. Many superstitions and misconceptions have grown up about the owl because of the mystery of the dark. (Or any other answer that is correct.)
4. Individual answers.

p. 115—*Names of Birds of Prey*

1. a. hawk
   b. owl
   c. owl
   d. hawk
   e. hawk
   f. owl
   g. hawk
   h. hawk
   i. owl
   j. hawk

2. Circle: Cooper's, sharp-shinned.
3. Draw lines connecting: 1 and 6; 2 and 4; 3 and 5.

p. 116—*Riddles about Birds of Prey*

Riddles: I. screech owl; II. barn owl; III. great horned owl; IV. sparrow hawk

Blanks:
1. no
2. no
3. in a hole in a tree
4. in a barn or other buildings
5. on a cliff high above the ground or in old hawk or crow nests

p. 117—*A Chart about Birds*

Individual answers.

p. 118—*The Work of Social Insects*

Bee Hive: Some examples are:

1. lay eggs (done)	1. queen bee (done)
2. keep food in the hive	2. workers
3. guard the entrance to the hive	3. workers
4. build combs	4. workers
5. gather nectar	5. workers
6. repair the hive	6. workers

Ant Hill: Some examples are:

1. care for the larvae	1. workers
2. keep the ant hill clean	2. workers
3. gather food	3. workers
4. bathe the larvae	4. nursemaid
5. carry the pupae	5. nursemaid
6. lay eggs	6. queen ant

p. 119—*What Do Ants Do?*

Meet the Queen: Some examples are:

1. flies away from the hill
2. finds a mate
3. finds a home
4. tears off her wings and eats them
5. lays eggs
6. lives in an apartment of her own

Meet the Workers: Some examples are:

1. make the ant hill

2. keep it clean
3. protect the hill
4. gather food
5. raise gardens
6. enlarge the hill

Nursemaids: Some examples are:

1. care for the baby ants
2. take the eggs from the queen to another room
3. carry the larvae to another room
4. feed the larvae
5. keep the larvae at a fairly even temperature
6. bathe the larvae
7. move the pupae to another room and keep it at an even temperature

Ants Which Store Honey: Some examples are:

1. The ant strokes the aphids to get honeydew.
2. The ant drinks the honeydew.
3. Ants gather aphid eggs.
4. The ants take care of the young aphids.
5. The ants which can hold the most food are chosen to be the honey casks.
6. Other ants pump honeydew into the honey casks.
7. The honey casks let the honey fall from their mouths to the mouths of workers.

On the Battle Line: Some examples are:

5. The winners make slaves of the larvae when they become adults.
6. The slaves do any work that is necessary.
7. The slaves live just as other ants do, except that they never go out to fight battles.

Many Kinds of Ants: Some examples are:

1. Farmer ants raise gardens in their ant hills.
2. The ants with large jaws grind the seed into a powder.
3. The carpenter ants bore holes in posts or trees.
4. Some ants are nearly an inch long. The bulldog ants in Australia have poisonous stings.

5. The larvae of the tailor ants spin silk threads which stick to leaves, holding together for their house.
6. Ants are sometimes made into a paste for food for man. Dried pupae are used for goldfish food.
7. Ants are sometimes a nuisance.

p. 120—*Ant Routes*

Individual answers.

p. 123—*The Metamorphoses of Insects*

See p. 99 of How and Why Experiments.

p. 124—*The Uses of Machines*

Individual answers.

p. 125—*Levers*

	F	*Weight*	*Force*
1.	end of spade	earth being shoveled	boy's right foot
2.	closed end of tongs	the sugar	fingers
3.	elbow	the orange	muscle
4.	wheel	the box	boy's muscles
5.	toe	(The weight is not shown in the picture. It is the body.)	muscle of the leg
6.	boy's right hand	the fish	boy's left hand
7.	base of pole	body of vaulter	muscles of legs
8.	upper boy's hands	upper boy's body	muscles of his legs

p. 126—*Definitions of Levers*

Blanks: Lever: move, heavy
First class lever: fulcrum, weight, force
Second class lever: weight, fulcrum, force
Third class lever: force, fulcrum, weight

Pictures: 1. fulcrum, weight, force
2. weight, fulcrum, force
3. force, weight, fulcrum

p. 127—*Descriptions of Machines*

1. Draw lines through: machine, simple machine.
2. Check: Wedge—car, wheel, change direction of force.
   Inclined plane—split wood, axe, rope.
   Pulley—splitting rails, push.
3. Wedge: simple machine, hatchet, axe, splitting shingles, splitting rails

   Inclined plane: simple machine, car, plank, mountain road, heavy box

   Pulley: simple machine, heavy box, rope, change direction of force, pull down
4. *a.* a simple machine like an axle or hatchet that can be used to split rails or shingles

   b. a simple machine which changes the direction of force that can be used to lift a heavy box by pulling down on the rope

   c. a simple machine like a mountain road which enables cars to move up them or a plank up which a heavy box could be pushed

p. 128—*First-Aid Practices*

1. (done)
2. One should not put his fingers in his mouth because they may have harmful bacteria on them.
3. Keep the covers on garbage cans.
4. Drain swamps or spray oil on stagnant water.
5. Get vaccinated against smallpox.
6. Any of the five rules on p. 149 of How and Why Experiments
7. Any of the five rules on p. 210 of How and Why Experiments
8. All the food that you eat should be clean and fresh.
9. Any of the three rules on p. 269 of How and Why Experiments
10. Any of the rules in the 3rd and 4th paragraphs on page 282 of How and Why Experiments
11. Form good habits.

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